Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Expanding Flexible Use of the 3.7 to 4.2 GHz Band	)	GN Docket No. 18-122
	)	

COMMENTS OF ACA CONNECTS – AMERICA'S COMMUNICATIONS ASSOCIATION ON THE DRAFT COST CATALOG AND LUMP SUM CATEGORIES AND AMOUNTS

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May 14, 2020

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ACA Connects – America's Communications Association ("ACA Connects") hereby responds to the *Public Notice* issued by the Wireless Telecommunications Bureau ("Bureau") of the Federal Communications Commission ("Commission") seeking comment on the preliminary cost category schedule ("Cost Catalog") for relocation expenses in the 3.7-4.2 GHz Band.[1]

I. INTRODUCTION AND SUMMARY

ACA Connects represents more than 700 medium and small multichannel video programming distributors ("MVPDs") that rely on C-band transmissions today to receive video programming and that will need to relocate from the bottom three hundred megahertz of the band as a result of the *Order*.[2] ACA Connects focuses its comments[3] in two areas:

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1 *Wireless Telecomms. Bureau Seeks Comment on Preliminary Cost Category Schedule for 3.7-4.2 GHz Band Relocation Expenses*, GN Docket No. 18-122, Public Notice, DA 20-457 (April 27, 2020) ("*Public Notice*"). The preliminary Cost Catalog is an Attachment to the *Public Notice*. *See Public Notice*, Attachment, "3.7 GHz Transition Preliminary Cost Category Schedule of Potential Expenses and Estimated Costs" (Apr. 27, 2020) ("Cost Catalog").

2 *Expanding Flexible Use of the 3.7 to 4.2 GHz Band*, GN Docket No. 18-122, Report and Order and Order of Proposed Modification, 35 FCC Rcd 2343 (2020) ("*Order*").

3 ACA Connects is supported in this effort by the analysis of Cartesian, a report of which is attached to these Comments. *See* Attachment. Cartesian is well known to the Bureau and Commission thanks to its close collaboration with ACA Connects to present the concerns of this country's medium and small MVPDs throughout the GN Docket No. 18-122 proceeding. Cartesian, for assistance with the effort of evaluating the sufficiency of the Cost Catalog and the formulation of an appropriate lump sum amount for MVPD

- That portion of the Cost Catalog preliminarily describing reimbursement of costs that may be incurred to relocate its members' earth stations to ensure that they receive and can continue to provide their customers with substantially the same service during and after the transition as before.
- A proposal for a lump sum amount for an MVPD earth station category that MVPD earth station operators can elect for all of their earth stations to migrate out of the lower 300 megahertz of the 3.7-4.2 GHz Band.

The *Order* explains that incumbents that transition out of the 3700-4000 MHz range into the upper 200 megahertz of the 3.7-4.2 GHz Band are entitled to reimbursement of their actual, reasonable relocation costs and that "[r]easonable relocation costs are those necessitated by the relocation in order to ensure that incumbent space station operators continue to be able to provide substantially the same or better service to incumbent earth station operators, and that incumbent earth station operators continue to be able to provide substantially the same service to their customers after the relocation compared to what they were able to provide before."[4] The Commission underscored that, in the case of incumbent MVPD earth stations, "comparability for video distribution services requires that the video quality of the end-to-end, programmer-to-viewer chain is at least as good as it is today."[5]

The Commission directed the Bureau "to establish a cost category schedule of the types of expenses that incumbents may incur" when they transition out of the 3700-4000 MHz range to the upper 200 megahertz of the 3.7-4.2 GHz Band.[6] As discussed herein, the preliminary Cost Catalog, while a productive first step, fails to capture many critical aspects of the transition

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earth stations, retained several subject matter experts, including David Higgins and Chris Patterson, with long experience in the industry. ACA Connects and Cartesian also benefitted from numerous discussions with ACA Connects' members of various sizes and geographies, larger non-member MVPDs, incumbent space station operators, programmers, vendors, and manufacturers.

4 *Order* at ¶ 194.

5 *Id.* at ¶ 194, n. 518.

6 *Public Notice* at 1.

related to the scope of the equipment and services that may be needed to transition MVPD earth stations, and to do so in the timeframes called for in the *Order*. Accordingly, ACA Connects recommends the following amendments to the preliminary Cost Catalog, which will support a successful transition of earth station facilities, ensure that relocated earth station operators obtain and can deliver to their customers substantially the same or better service – as the *Order* requires – and provide for reimbursement of reasonable costs necessary to the transition:

- Maintain the cost categories that appear in the Cost Catalog, and the price ranges, expressly applicable receive-only earth stations;
- Make clear that certain cost categories already included in the preliminary Cost Catalog applying to incumbents other than receive-only earth stations, and their presumed reasonable cost ranges, also are associated with receive-only earth stations to the extent such costs may be involved in the transition of such stations;
- Include cost categories that are missing in the Cost Catalog schedule that may reasonably be involved in the transition of some receive-only earth stations and provide a presumed reasonable range of costs for them;
- Include an MVPD receive-only earth station category for lump sum election purposes because the preliminary lump sum categories in the Cost Catalog, based primarily on antenna size, do not appropriately reflect the particular characteristics of the "average" MVPD receive-only earth station; and
- Include a lump sum amount of $760,500 for the MVPD receive-only earth station category, which is based on conservative assumptions reflecting sufficiently-common elements of the transition of MVPD earth stations to the upper 200 megahertz of the 3.7-4.2 GHz Band.

II. THE IMPORTANCE OF ENSURING THE COST CATALOG IS AS COMPREHENSIVE AS POSSIBLE

ACA Connects submits that the Cost Catalog will play an extremely important informational role for its members as they navigate through the novel waters of the 3.7-4.2 GHz Band transition under the framework in the *Order*. As a result, it is vital that the Bureau and its consultant consider the inclusion of any categories of equipment or work activity that at least some MVPD earth stations are likely to encounter to ensure they continue to receive and deliver to their customers "substantially the same service" as before the transition and that "the video

quality of the end-to-end, programmer-to-viewer chain is at least as good as it is today." ACA Connects and Cartesian have endeavored to provide that comprehensiveness, as covered in detail in the Attachment to these comments.

Properly capturing the full range of potential cost categories is essential to provide guidance to the Relocation Payment Clearinghouse ("Clearinghouse") and other stakeholders on transition costs reasonable to be reimbursed, to stakeholders regarding the scope of potential relocation activities, to the Bureau regarding establishment of lump sum categories and amounts, and to incumbent earth station operators to make their elections whether to accept the lump sums. We explain each of these reasons below.

1. The Cost Catalog Will Provide Guidance to the Clearinghouse and Other Stakeholders on Transition Costs Reasonable to Be Reimbursed. The Cost Catalog will be a primary guide to the Clearinghouse and other stakeholders of the scope of cost types that earth station relocation may reasonably need to meet the standards of the *Order*, and thus which costs are entitled to reimbursement where they can be supported as necessary for relocation of particular earth station facilities. As the *Order* makes clear, "[r]eimbursement submissions that fall within the estimated range of costs in the cost category schedule issued by the Bureau shall be presumed reasonable."[7] While the Clearinghouse will have to determine, based on the documentation submitted to it, whether the *types* and *multiples* of costs incurred in any given

[7] *Order* at ¶ 262. Because the Clearinghouse is designed to "consider the submission and supporting documentation, and any relevant comparable reimbursement submissions," when it "determine[s] the reasonableness of reimbursement requests," *see id,* ACA Connects understands that submissions that seek reimbursement above the presumptively reasonable ranges, as well as those that seek reimbursement for any items not on the Cost Catalog schedule that support such requests with adequate documentation that such expenses were necessary to ensure substantially the same service on an end-to-end basis, would still qualify for reimbursement.

earth station relocation were reasonable, guidance as to the types of costs that may be incurred – and a presumptively reasonable range for such costs –will streamline the Clearinghouse's task. As a consequence, reimbursement also should be expedited if the Cost Catalog is as comprehensive as reasonably possible. To the extent any categories of expenses that may be reasonably involved in a relocation of an earth station are excluded from the Cost Catalog, the Clearinghouse will have the double additional burden of determining whether such costs may be reasonably incurred and at what cost. The absence of such categories in the Cost Catalog, and presumed reasonable cost ranges, could lead to greater uncertainty and disputes among stakeholders and with the Clearinghouse over reimbursement.

2. The Cost Catalog Will Provide Guidance to Stakeholders Regarding the Scope of Potential Relocation Activities. A more complete listing of equipment, support systems, and work activities in the Cost Catalog that may be necessary for earth station relocation is important to signal to parties responsible for relocation of incumbent earth stations what costs for the equipment, upgrades (where necessary for the transition), space, power facilities, and other items that may be involved will be recognized as legitimate expenses in a well-documented request for reimbursement. This is critical whether space station operators electing accelerated relocation are responsible for submitting earth station relocation expenses to the Clearinghouse or the earth station operators are dealing directly with the Clearinghouse (*e.g.*, in a non-accelerated transition scenario where the earth station operator has not elected lump sum payments). Consequently, a more comprehensive Cost Catalog would help reduce the potential for uncertainty and disputes among stakeholders regarding what may be considered necessary to ensure substantially the same service and qualify for reimbursement. More broadly, greater agreement among stakeholders at the onset means that the transition is less likely to run into delays that would

prevent new users from offering new services in the band within the *Order's* proposed timeframes.

From the many discussions ACA Connects has had with its members since the release of the *Order*, there is concern that some space station operators and even the Commission and the Clearinghouse may take an overly simplified view, at least in some cases, on what is needed to transition the earth stations of small- and mid-size cable operators and ensure comparable end-to-end service as exists today in light of satellite and technology changes. Invariably for small and medium MVPDs, relocation of earth stations will involve much more than a simple repoint, retune, and filtering, as detailed in the attached Cartesian report. Consequently, ACA Connects takes exception to the application of the suggestion in the Cost Catalog that "the majority of earth stations can be migrated through the[] simple mechanisms" of "a simple filtering, retuning, or repointing of various earth stations" to MVPD earth stations as a whole.[8] Indeed, the *Order* notes that, in the event that eligible space station operators seek to complete the transition by the *Order's* accelerated deadlines and thereby receive accelerated relocation payments, "space station operators must not knowingly cause the incumbent earth stations that receive its transmission to temporarily or permanently lose service during or after the transition and must take all steps necessary to allow incumbent earth station operators to continue to receive substantially the same service during and after the relocation that they were able to receive before the transition."[9]

A properly-scoped Cost Catalog will align earth station operators' expectations with the promise of the *Order* that the full range of reasonable and necessary transition costs will be

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8 Cost Catalog at 5.

9 *Order* at ¶ 171.

reimbursed while maintaining substantially similar (or better) service during and after the transition. ACA Connects, therefore, applauds the Bureau for beginning the process of seeking comment on a preliminary Cost Catalog. The process will help enlighten space station operators about the needs of MVPD earth stations. However, given that certain Cost Catalog potential expenses and estimated costs can only be derived from knowing the final Transition Plans of the space station operators, ACA Connects urges the Bureau to hold off on finalizing the Cost Catalog until *after* the space station operators submit their final Transition Plans by August 14, 2020, and the Bureau and the public have had time to review the details and provide further comment. Along these lines, as noted later in these comments, the Bureau also should only finalize the lump sum categories and amounts *after* the Transition Plans are finalized so that incumbent earth station operators have as complete information as possible *before* making their election whether to accept lump sum payments or not.

3. The Cost Catalog Will Provide Guidance to the Bureau Regarding the Establishment of Lump Sum Categories and Amounts. A fully-developed schedule of costs, and ranges of what will be considered presumptively reasonable for each cost category, will serve as an essential tool for the Bureau – with input from stakeholders, especially those whose facilities are being transitioned – in developing and finalizing appropriate lump sums reflecting the average costs for each category of incumbent earth station facility for which a lump sum will be developed. As the lump sum is to represent the "average, estimated costs" of relocating incumbent earth stations in each earth station category ultimately designated by the Bureau,[10] having a full schedule of the various cost types (and the associated presumptively reasonable cost ranges) that may be involved over the universe of impacted earth stations is vital. In addition,

[10] *Id.* at ¶ 202. *Accord Public Notice* at 2-3.

ACA Connects urges the Bureau to complete its lump sum determinations only after the incumbent space station operators' Transition Plans are final. Otherwise, there is an unacceptable risk of understating the average costs.

Naturally, as detailed in further herein and discussed in the Attachment, having the schedule of cost types and presumptively reasonable ranges is an essential, but not the only, input required to establish the lump sum amounts. As Cartesian explains in detail, in the average earth station relocation in the MVPD receive-only earth station category (which ACA Connects urges the Bureau to adopt), numerous costs will occur multiple times, such as antenna replacement and integrated receiver/decoders ("IRDs"), and the costs ancillary to these elements. The Bureau, thus, should also take account of potential for recurrence of costs for a single earth station relocation when establishing the lump sum amounts.

4. The Cost Catalog Will Provide Guidance to Incumbent Earth Station Operators to Make Their Elections Whether to Accept the Lump Sums. A properly-comprehensive Cost Catalog, in combination with the Bureau-determined lump sum payments, will be an essential aid to incumbent earth station operators as they make their individual decisions on whether to elect lump sum payments for all of their earth stations (and assume full responsibility for the migration of their earth stations without further opportunity for reimbursement from the Clearinghouse) or have the space station operator perform the necessary work and seek reimbursement for the transition of their earth stations.

In this regard, it also will be critical for earth station operators to see the final Transition Plans of the space station operators before making that decision. ACA Connects expects that space station operators will explain in their Transition Plans matters such as what satellite transmissions – specified by compression standard, modulation, resolution, satellite and

frequency/transponder – will be discontinued or are changing and when. For those that are changing, the space station operators' Transition Plans should address what the new compression standards, modulations, resolutions, satellites, and frequencies/transponders will be and how dual illumination will be implemented. ACA Connects expects space station operators will explain in their Transition Plans how they will ensure that the signal quality received and outputted by any equipment, software, or licenses provided will be substantially the same or better as the quality provided before the transition. This is critical information for earth station operators to confirm that they will receive and deliver comparable end-to-end service and what changes and costs may be required for their earth station facilities to achieve such service.

Accordingly, ACA Connects reiterates its request that the lump sum elections only take place after the space station operators' Transition Plans are final.[11] Otherwise, MVPDs like ACA Connects' members, as well as other incumbent earth station operators, will be shooting in the dark when making their choices. Indeed, ACA Connects submits that the finalization of the Transition Plans is a necessary precursor to the Bureau completing its task of establishing lump sum amounts that satisfy the applicable standards in the *Order*. Nothing in the *Order* prevents the Bureau from announcing the lump sums after the Transition Plans are finalized, and doing so will ensure that ACA Connects members and other earth station operators have sufficient information to make rational economic decisions as part of the process established in the *Order*,

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[11] *See Ex Parte* Meeting Notice Letter from Pantelis Michalopoulos, Steptoe & Johnson LLP, Counsel for ACA Connects, to Marlene Dortch, Secretary, Federal Communications Commission, GN Docket No. 18-122, 5 (Feb. 18, 2020) ("ACA Connects Feb. 18 Letter"). The *Order* only requires that the earth station operators' elections must be made 30 days after the Bureau provides public notice of the final lump sum categories and amounts, and does not set a specific date for the Bureau to act. *See Order* at ¶ 203; 47 C.F.R. § 27.1419.

just as the Commission has taken steps to ensure that potential 3700-3980 MHz auction participants receive as comprehensive information as possible before the auction commences.

III. SPECIFIC COMMENTS ON THE PRELIMINARY COST CATALOG

The Bureau solicits comment in the *Public Notice* on the Cost Catalog, "including whether the preliminary categories and estimated expenses for each are reasonable" and whether "additional expense categories . . . should be eligible for reimbursement and prices that should be associated with those categories."[12] The preliminary Cost Catalog presents a solid first step toward development of a schedule of equipment and work activity expenditures that may reasonably be required to transition receive-only earth stations. Specifically, Section III of the Cost Catalog covers a variety of earth station transition-related costs that may be incurred which directly pertain to MVPDs' segment of the C-Band ecosystem, receive-only earth station downlinks.[13] ACA Connects agrees that the costs identified in that section that are expressly applicable to receive-only earth stations are applicable and relevant, and that the proposed cost ranges are reasonable.[14]

However, as explained below and in much greater detail in the Attachment, while the Cost Catalog recognizes certain other types of costs with regard to some incumbent facilities other than receive-only earth stations, it does not consistently and clearly recognize that similar costs will be involved in the transition of receive-only earth stations. Further, there are some types of costs that will be necessary to ensure substantially the same service on an end-to-end basis which must be added to the Cost Catalog. Through the attached Cartesian report, ACA Connects sets out to provide the Commission with information to correct any such omissions.

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12 *Public Notice* at 2.

13 *Cost Catalog* at 6-10.

14 *See, id.,* especially Tables III-A-1, III-A-2, III-B-1, III-B-2. *See also* Attachment, Section 2 (p.9) and Section 5.

ACA Connects and Cartesian consulted with a number of ACA Connects members to gather information about their current operations and what steps they anticipate would be necessary to transition their earth station operations to the upper 200 megahertz of the band. ACA Connects and Cartesian also reached out to several space station operators, non-member cable operators, vendors, and programmers to discuss these subjects. What these discussions made clear is that there is an extremely large number of scenarios and variability in how MVPD earth station relocations to the upper 200 megahertz under the framework adopted in the *Order* could play out (and a lot of current uncertainty among all stakeholders).

The migration of incumbent MVPD earth stations to the upper 200 megahertz of the 3.7-4.2 GHz Band will frequently require new or upgraded equipment used to receive, decode and transcode signals, such as IRDs as well as replacement antennas, supporting systems, new construction, increased real estate or leasing costs, zoning, and testing equipment to ensure signal quality. Temporary antennas, all associated space, equipment, and power supplies, and other supporting elements, often will be needed to ensure there is substantially similar (or better) service throughout the transition without interruption. The new permanent and temporary equipment at MVPD earth stations required for a successful transition as contemplated in the *Order* will commonly generate other "inside" costs, such as increases in capital or operating electrical or heating, ventilation, and air conditioning ("HVAC") costs, increased licensing costs for new IRDs, additional racks, uninterrupted power supplies, and other ancillary but necessary costs due to a lack of physical space to house all the equipment needed to accommodate a simultaneous dual illumination of all satellite transmissions received by MVPD earth stations during the transition.

The preliminary Cost Catalog indicates that incumbent Fixed Services stations may incur a wide variety of incidental costs to the transition of those stations out of the 3.7-4.2 GHz Band, including relocation project costs, site acquisition costs, architecture and engineering costs, survey costs, and environmental costs.[15] Although, without a doubt, some of the foregoing types of expenses are included in the Cost Catalog in a way that makes clear that they could apply to the relocation of receive-only earth stations and qualify for reimbursement when necessary to ensure substantially the same service, not all such costs are included and identified in the Cost Catalog as potential transition costs for receive-only earth stations.

Accordingly, focusing on those entries in the Cost Catalog most relevant to ACA Connects members' MVPD earth station facilities, Cartesian examines in the Attachment the sufficiency of the coverage in the cost schedule of the Cost Catalog that clearly applies to receive-only earth stations, which currently are subsumed within broader categories of section III.A "Filtering/Retuning/Repointing" and section III.B "Earth Station Migration and Filtering Costs." In so doing, Cartesian found that some of the cost elements in the document in the preliminary Cost Catalog associated with gateway stations and bi-directional earth stations also are equally relevant to developing costs for receive-only earth station migration, and should be clearly identified as reimbursable receive-only transition costs when necessary and sufficiently documented. In addition, some of the cost categories recognized for Fixed Services (Section IV of the Cost Catalog) also are of the sort that are equally relevant to reasonable relocation costs that receive-only earth stations will potentially face.

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15 Cost Catalog at 14-19.

The Bureau inquires in the *Public Notice* whether the preliminary Cost Catalog "cover[s] every situation,"[16] ACA Connects submits that, after a thorough review of the types of costs its members may incur during a transition to ensure that they continue to receive substantially the same service, the preliminary Cost Catalog does not cover every situation. While, given the complexity and variety of earth station transitions that may occur, perhaps the Bureau should not expect that the final Cost Catalog will do so, that should not keep the Bureau from making a best effort to ensure comprehensiveness for the reasons given in Section II above. Accordingly, with the objective of trying to cover the vast majority of scenarios its members may face and make the Cost Catalog as exhaustive as possible, ACA Connects offers its additions to the Cost Catalog, along with justifications, in the Attachment. In line with the *Public Notice*, where information is publicly available, Cartesian has included in the Attachment "information on specific prices, as well as more general information on the costs that [MVPD] incumbents expect to incur."[17]

In connection with the presumed reasonable price ranges included in the preliminary Cost Catalog as augmented by the additional cost categories that should be included for receive-only earth stations, ACA Connects wishes to underscore that, under an accelerated relocation, it is expected that the equipment and other material needed to ensure timely transitions may be in short supply and market prices for such material and equipment (and the labor for installation) may increase. Exacerbating the potential strains on supply given the unprecedented and humongous task of migrating thousands of earth stations across the contiguous United States, the ongoing impacts of the COVID-19 pandemic may put increased strictures on the availability of equipment, material, and labor to complete transition requirements. These market forces all must

16 *Public Notice* at 2.
17 *See id.*

be taken into account, as Cartesian explains in the Attachment, in determining what the reasonable cost ranges are for numerous items within the Cost Catalog. Indeed, RKF Engineering Solutions LLC, which assisted the Bureau with developing the preliminary Cost Catalog, recognizes that "[s]upply and demand constraints may impact future costs."[18] However, ACA Connects' and Cartesian's review of the cost ranges for the line items in the preliminary Cost Catalog for receive-only earth stations suggests that the ranges do not take account of these prospective pressures on current marketplace costs. Similarly, ACA Connects and Cartesian, in offering additions to the Cost Catalog do not, for consistency's sake, attempt to anticipate the future evolution of market drivers. However, ACA Connects urges the Bureau and the Commission to instruct the Clearinghouse to take into account such market changes when evaluating requests for reimbursement that may be in excess, for some line items, of the presumed reasonable ranges in the Cost Catalog adopted in the present.

IV. SPECIFIC COMMENTS ON CONSTRUCTION OF LUMP SUM CATEGORIES AND THE DEVELOPMENT OF LUMP SUM AMOUNTS

A. The Adoption of an MVPD Earth Station Category for Lump Sum Purposes

The Bureau's *Public Notice* sought comment on categories of "various classes of earth stations" for which lump sum amounts could be generated, including several "preliminary" categories in the preliminary Cost Catalog.[19] Prior to the *Order*'s adoption, ACA Connects argued that "[a]t a minimum, the different classes of earth station operators should include multichannel video programming distribution ('MVPD') earth station operators and non-MVPD earth station operators."[20] The Commission agreed, finding in the *Order* that the "Bureau should

18 Cost Catalog at 1.
19 *Public Notice* at 2.
20 *ACA Connects Feb. 18 Letter* at 5-6.

identify lump sum amounts for various classes of earth stations—e.g., MVPDs, non- MVPDs, gateway sites—as appropriate."[21] Yet, the Bureau's preliminary Cost Catalog preliminarily identifies nine categories of earth station that are distinguished solely by size of antenna and number of feeds. There is no MVPD category in the preliminary Cost Catalog, nor do any of the preliminarily identified categories serve as a suitable proxy for an MVPD earth station category.

As ACA Connects explained previously, "the costs for relocating earth stations of cable operators that receive hundreds of satellite transmissions over multiple dishes will be vastly different than from those of others, such as earth stations of radio stations receiving a single radio network over a single dish."[22] Cartesian explains in the Attachment (Section 4) the antenna dimensions by which the Bureau in the Cost Catalog preliminarily categorizes earth stations is unlikely to be a strong determinant of transition costs for most MVPD earth stations: "[W]hile antenna size is one factor for consideration, more important are the volumes of antennas that will be required, facility readiness for new equipment (e.g., adequate space for installations, where required), and the channels currently received and distributed by the headend."[23] Cartesian goes on to conclude that non-MVPD earth stations will "have a substantially different profile with respect their transition requirements [than that of MVPD earth stations], such as number of antennas, associated IRDs, and other infrastructure equipment."[24] Accordingly, ACA Connects submits that the Bureau should adopt an MVPD earth station category for lump sum purposes separate from any category or categories that might apply to non-MVPD earth stations.[25]

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21 *Order* at ¶ 262.

22 *ACA Connects Feb. 18 Letter* at 5-6.

23 Attachment, Sec. 4, p. 21.

24 *Id.*

25 ACA Connects does not have sufficient insight into the relocation of other types of earth stations to take a position on other categories.

B. The Calculation of the Lump Sum Amount for the MVPD Earth Station Category

In addition to proposing that there be an MVPD earth station category for purposes of lump sum elections, ACA Connects – supported by Cartesian's analysis in Section 4 of the Attachment – proposes a lump sum amount for that category of $760,500. Cartesian describes in detail the methodology and elements used to develop the lump sum amount for this category. Specifically, as requested in the *Public Notice*, Cartesian identifies "the specific costs and prices that should be included in the lump sum amount" for the MVPD category.[26]

The *Order* directed the Bureau to announce a lump sum amount based on the average, estimated cost to relocate incumbent earth stations within a given category of earth station to the upper 200 megahertz of the 3.7-4.2 GHz Band.[27] In order to calculate a lump sum amount for the MVPD earth station category that ACA Connects recommends above, Cartesian relied upon its industry expertise and numerous discussions it and ACA Connects recently had with ACA Connects members, several large non-member MVPDs, and other stakeholders with extensive knowledge and experience in the MVPD industry. These discussions reviewed the architecture and operation of MVPD earth stations and what the transition of the 3.7-4.2 GHz Band would likely entail, which will depend in no small matter on the details of the space station operators' Transition Plans.

Cartesian based its estimate on available information about the characteristics of registered MVPD earth stations, the steps that space station operators and MVPD programmers are likely to take to facilitate the transition, and good engineering practice. Cartesian developed a profile of an "average" MVPD earth station for lump sum purposes by looking for

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26 *Public Notice* at 3.

27 *Order* at ¶ 202.

characteristics it expects to be sufficiently common at eligible MVPD earth stations. In other words, Cartesian looked for those equipment requirements and the upgrade, systems, and work activity anticipated in approximately fifty percent or more of cases. Using this criterion, Cartesian built up a lump sum amount that reflects the "average" transition of the "average" earth station. To address the *Order*'s requirement that, during and after the transition, space station operators are obligated to provide substantially the same service to that which is being provided to MVPD customers today, Cartesian included expenditures in the lump sum that address reliability and uptime, such as antenna configurations and sizes, relevant equipment and systems, as well as associated space, power, and HVAC requirements.

At the same time, reflecting the conservatism of Cartesian's lump sum calculation, Cartesian excluded from the calculation those costs that most MVPD earth stations would not incur, including both large and small ticket items.[28] In cases where multiple units of equipment, systems, associated work, or other cost categories would be involved in a sufficiently common number of cases to be part of the lump sum calculation, Cartesian assumed a conservative but reasonable number of occurrences for the transition needs of the "average" earth station profile. As for the cost used for each of the expenses that were included under this approach to arrive at a lump sum recommendation, Cartesian consistently applied the arithmetical mid-point of the range for that cost category.

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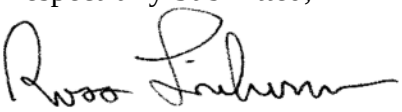
[28] ACA Connects underscores that the exclusion of such items from the lump sum calculation is not at all to say that such expenses, depending on the circumstances of an earth station's transition requirements, would not be a reimbursable expense where the lump sum is not elected by the earth station operator.

ACA Connects submits that Cartesian's approach provides the most reasonable means of estimating the lump sum for the MVPD category at this juncture.[29] Further refinements, while possible, would, in ACA Connects' estimation, first require the finalization of the Transition Plans of the five incumbent space station operators, which only will occur in three months, and the finalization of the cost schedule in the Cost Catalog. ACA Connects submits that it would be appropriate to revisit the lump sum calculation once the Transition Plans and the final Cost Catalog schedule (minus the lump sum amounts) are available.

V. CONCLUSION

For the foregoing reasons, ACA Connects submits that the Bureau should adopt the changes to the preliminary Cost Catalog discussed herein and detailed in the attached report from Cartesian to ensure that on an end-to-end basis MVPD earth stations will receive and can deliver to customers substantially the same service as they do today during and after the transition from the lower 300 megahertz of the 3.7-4.2 GHz Band.

Respectfully Submitted,



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May 14, 2020

[29] Cartesian notes that other, more aggressive approaches for calculating lump sum amounts may exist, but would have required an extensive, costly, and time-consuming survey which was not possible within the limited time required to respond to the *Public Notice*.

ATTACHMENT

C-Band Transition Cost Assessment

Response to GN Docket No. 18-122

14 May 2020

Prepared for:

Confidentiality

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1. Overview

1.1. Context of Assessment

In the *Expanding Flexible Use of the 3.7 to 4.2 GHz Band Report and Order* (Order), the Federal Communications Commission established a framework by which fixed satellite service (FSS) space station operators, incumbent FSS earth station operators, and incumbent Fixed Service licensees must relocate from the lower 300 megahertz of the 3.7-4.2 GHz Band into the upper portion (C-Band Transition). Recognizing this transition will impact these users, the Order provides for reimbursement for their reasonable relocation costs.

The Order defines reasonable relocation costs as those "necessitated by the relocation in order to ensure that incumbent space station operators continue to be able to provide substantially the same or better service to incumbent earth station operators, and that incumbent earth station operators continue to be able to provide substantially the same service to their customers after the relocation compared to what they were able to provide before." Further, the Commission clarifies that "comparability for video distribution services requires that video quality of the end-to-end, programmer-to-viewer chain is at least as good as it is today." In the event that eligible space station operators seek to complete the transition by the Order's accelerated deadlines and thereby receive relocation payments, these operators "must not knowingly cause the incumbent earth stations that receive its transmission to temporarily or permanently lose service during or after the transition and must take all steps necessary to allow incumbent earth station operators to continue to receive substantially the same service during and after the relocation that they were able to receive before the transition."

On April 27, 2020, the Wireless Telecommunications Bureau (the Bureau) solicited comment on its "3.7 GHz Transition Preliminary Cost Category Schedule of Potential Expenses and Estimated Costs" (Cost Catalog). The Cost Catalog is intended to provide a range of reasonable transition costs that incumbents may incur. The Relocation Payment Clearinghouse that will oversee the cost-related aspects of the transition is required to presume as reasonable all receipts received from eligible parties that fall within the estimated range in the final version of the Cost Catalog. The Bureau also sought comment on a list of preliminary classes of earth stations for which lump sum amounts should be adopted and what the various lump sum amounts should be.

Cartesian, on behalf of ACA Connects, evaluated the scale, scope, and timeline of the proposed transition for MVPD earth station owners. We also conducted a detailed review of the preliminary cost categories and estimated expenses in the Cost Catalog that are relevant to the relocation of MVPD earth stations. Moreover, we reviewed the cost ranges for the expenses identified in the Cost Catalog, and determined whether the Cost Catalog omits any goods or services that will be necessary for at least some MVPD earth stations to effectuate the C-band transition. Further, Cartesian reviewed the Cost Catalog's various classes of earth stations that may choose to receive a lump sum payment in lieu of their actual reasonable relocation costs, and evaluated what is the category of earth station that is most appropriate to cover MVPD earth stations and calculated the correct lump sum amount for that category.

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To conduct our evaluation, Cartesian collaborated with subject matter experts[1] with significant expertise and experience in the earth station engineering and operator areas in video programming distribution and engaged a broad range of stakeholders including satellite operators, MVPDs, programmers, and vendors.

1.2. Key Findings & Recommendations

This proposed transition will have sweeping effects on MVPDs. The effort to maintain service for these parties within the bounds of the Order is doable, but will be significant, and if the space station operators seek to complete the transition by the Order's accelerated deadlines, the effort will be further complicated by the ambitious timetable.

Our findings lead us to recommend amendments to the Cost Catalog prior to finalization. While the Catalog includes some costs that will be incurred in transitioning MVPD earth stations to the upper 200 megahertz with appropriate cost ranges, it does not include many other costs that will be required by MVPDs to ensure continuity of earth station reception and delivery of MVPD service to customers at substantially the same levels during and after the transition. The costs we've identified are reflective of the scope of the proposed transition, the possibility of it being done in an accelerated timeframe, and the variety of factors that need to be considered for MVPD earth stations who each have unique circumstances in which these factors result in costs. Our findings are detailed in the following sections:

- **Section 2:** Catalog Costs Applicable to Earth Station Migration
  - In this section, we identify those costs enumerated in the Cost Catalog that are relevant to MVPDs. These include costs that the Catalog itself associates with the transition of receive-only earth stations, all of which we find appropriate (including the presumed reasonable price ranges set out for them). The Cost Catalog also lists other costs that are relevant to MVPD earth station transitions, but it currently does not directly link them to MVPD earth stations. As we explain below, the Bureau should deem MVPDs eligible to recover such costs and should clarify that, as with other catalog costs, MVPDs' reimbursement amounts will be presumed reasonable when they incur costs that fall within the estimated cost ranges.
- **Section 3:** Additional Earth Station Migration Costs
  - Here, we identify costs applicable to receive-only earth stations that were not mentioned in the Cost Catalog and provide reasonable low and high pricing amounts.
- **Section 4:** Proposed Lump Sum
  - In this final section, we recommend that the Bureau add an MVPD earth station category to its list of those for which the Bureau should provide a lump sum amount. Building on the work outlined in Sections 2 and 3, we propose a lump sum amount for this MVPD earth station category.

The above findings and recommendations are based on publicly available information at the time of filing, as well as discussions with numerous parties that will be involved in the transition. However, certain assumptions may require updating as further information becomes available, such as details of the space

[1] SMEs include David Higgins, former Vice President of Video Quality & Reliability for Comcast and Chris Patterson, former Executive Director of Video Quality & Reliability for Comcast (a copy of their CVs is appended as an exhibit to this report).

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station operators' transition plans (e.g., scope and scale of compression and modulation changes) once they are filed (in preliminary form) with the FCC on June 12, 2020, and then in final form on August 14, 2020.

1.3. Future Impacts on Pricing

The low and high amounts for costs identified in the Cost Catalog related to MVPD earth station expenses were considered reasonable for periods of normal demand. However, increases in demand for certain goods and services across the industry due to the accelerated timetable could drive prices higher through the end of 2023 once the transition begins. The unprecedented COVID-19 pandemic could have an even greater impact on prices. The current health emergency has disrupted international supply chains across many industries, and stay-at-home restrictions have limited the provision of certain services. If these disruptions and restrictions continue into next year and beyond, it can be anticipated that delays in equipment deliveries, availability of contractors, and most other related activities under an already extremely ambitious schedule will be exacerbated, which in turn may cause the price ranges for the Cost Catalog items to exceed the current upper-end figures

For the purposes of this assessment, we have accepted the cost ranges proposed in the preliminary Cost Catalog, but note that some of the upper ranges may need to be increased to reflect the actual costs that MVPDs are likely to incur should COVID-19 related business restrictions continue for longer than a few more months and in light of overall increases in demand relative to supply due to the Order's timetable.

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2. Existing Catalog Costs Applicable to Earth Station Migration

Section III of the cost catalog covers Earth Station Migration and Filtering Costs. Within that section, Tables III-A-1, III-A-2, III-B-1, III-B-2, and III-D-1[2], directly pertain to MVPDs' segment of the C-Band ecosystem: receive-only earth station downlinks. We agree that the costs identified in these tables are applicable and relevant, and that the proposed cost ranges are reasonable as applied to receive-only earth stations.

Other sections of the Cost Catalog include potential expenses and estimated costs that are relevant and reasonable for MVPD earth station downlinks, but these expenses do not appear in Section III of the Cost Catalog. Many of these types of costs are enumerated in the Fixed Services portion of the Cost Catalog, Section IV. These types of costs vary, but many derive from when an MVPD earth station location is unable to undertake the typical modifications necessary to continue receiving a satellite transmission. For example, these expenses may be incurred when an MVPD earth station must install a new or larger antenna and they lack the physical space for its proper placement. In these instances, the earth station operator may incur costs associated with finding an alternative site for a satellite antenna, including relevant real estate and zoning costs, and installing appropriate signal processing and transport from the location of the antenna's new location back to the earth station. Likewise, these types of expenses could be incurred if the headend of an earth station is not large enough to support additional equipment (e.g., new IRDs). In these cases, an MVPD earth station owner may need a new structure, supplemental power, an increase in HVAC capacity, as well as other relevant costs.

To address this missing potential expense, the Cost Catalog should include the costs outlined below, which are found elsewhere in the Cost Catalog, as potential reimbursable costs for MVPD receive-only earth stations. Additional details and justifications are provided below.

2.1. Gateway RF Downlink Chain (Table III-A-4)

In the event an MVPD earth station operator must install an antenna at a site distant from the earth station, there will be fiber connectivity costs associated with the transport of the low-noise block downconverter (LNB) signals back to the earth station/headend for processing. This cost has been contemplated for gateway earth stations, and we find the low and high ranges to be appropriate for that purpose. Since the Fiber System costs in Table III-A-4 table are similarly relevant to costs potentially incurred by MVPD earth stations, they should also be designated as such in the Cost Catalog.

Figure 1. Table III-A-4: Gateway - RF Downlink Chain

Cost Category	*Low*	*High*
RF Downlink Chain for Extended/Full Performance Antenna Configuration		
Fiber System	$ 45,000	$ 55,000

[2] In particular, we believe the "Receive Only Earth Station Relocation Cost," the "Receive Only Multi-beam Earth Station Relocation Cost," and "Application to Modify Existing Earth Station License and Coordination Report" categories are relevant to MVPD earth station relocation costs.

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2.2. Bi-Directional Earth Station Equipment (Table III-B-3)

MVPD earth station sites may also require equipment detailed in this table, particularly Core Network Components and Platform & Network Installation/Testing, as part of the transition to ensure they can provide substantially the same service following the migration.

Cost items such as line cards, modems, and other core network components are relevant for MVPD sites as well as bi-directional earth stations.

Figure 2. Table III-B-3: Bi-directional Earth Station Equipment

Cost Category	*Low*	*High*
Additional Line Cards for Transition	$ 6,000	$ 10,000
Additional Modems for Transition	$ 2,000	$ 8,000
Additional Chassis	$ 3,000	$ 10,000
Core Network Components - Routers, Switches, Server (per component)	$ 1,000	$ 30,000
Platform and Network Installation/Testing	$ 9,000	$ 17,000

2.3. Relocation Project Costs (Table IV-B-1)

The transition of the C-band will require a variety of work to be performed at MVPD earth station locations over an extended period of time, such as RF filter installations, IRD/transcoder installations, proper management of HVAC and power, and other services. Interdependencies between construction activity (e.g., new antenna installations), equipment deliveries, and installations – as well as coordination with programmers and satellite providers – necessitate careful oversight, and such project costs should appear in the Cost Catalog for receive-only earth stations.

Coordinating the performance of these activities within the deadlines outlined in the Order by in-house employees and contractors without causing service outages and disruptions will be work on its own. For each MVPD earth station, it will be a task for a dedicated, on-site project manager.

Table IV-B-1 of the Cost Catalog includes expenses associated with project management for Fixed Service Relocation efforts with reasonable estimated costs.[3] Since these types of costs will be incurred with respect to receive-only earth station relocations, the Cost Catalog should designate them explicitly as expenses for earth station operators.

Figure 3. Table IV-B-1: Fixed Service Relocation Project Costs

Cost Category	*Low*	*High*
Project Management of the Transition, if needed (cost per hour)	$ 62	$ 200
Address Transition Timing and Coordination Issues with Other License Holders, if needed	$ 850	$ 2,750

[3] In the event that the satellite operators do not elect to satisfy the accelerated deadlines, MVPD earth stations will be required to "address transition timing and coordination issues with other license holders," like the satellite companies and programmers who are themselves licensees, and will need to "Prepare and/or Review Reimbursement form[s]" when dealing directly with the Clearinghouse.

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Prepare and/or Review Reimbursement form	$ 250	$ 2,750

2.4. Site Acquisition Costs (Table IV-D-1)

When new downlink antennas are required to be installed at an MVPD earth station site or at a site nearby, which could be needed when there are satellite or technology changes made by space station operators or programmers as part of the transition, local zoning approval may be necessary. Typically, obtaining zoning approval involves the submission of relevant site plans and elevations. In some cases, engineering designs and reviews are also needed to obtain construction approvals and permits. These types of potential expenses and their estimated costs were included in Table IV-D-1 for Fixed Service Operators in the Cost Catalog. These costs are also relevant for MVPD earth stations and should be deemed as such.

Figure 4. Table IV-D-1 Site Acquisition Costs

Cost Category	*Low*	*High*
Search Ring for new viable tower or ground space, confirm zoning and permitting process, site candidate application in existing asset, lease package or ground lease	$ 7,500	$ 10,000
Obtain building permits from local zoning authorities (cost of preparation, submission and prosecution of necessary forms or applications)	$ 1,500	$ 6,000
Obtain local permits other than for zoning (cost of preparation, submission, and prosecution of necessary forms or applications)	$ 500	$ 2,500

2.5. Architecture / Engineering Costs (Table IV-D-2)

We recommend the potential expenses outlined in Table IV-D-2 for Fixed Service operators below be made explicitly applicable to receive-only earth stations, as they will often incur similar relocation costs. Although the precise reasons why these costs may arise for an earth station location may be slightly different than for Fixed Service operators, the potential expenses and estimated costs apply the same. In the two cases below, the costs arise due to the need to install new structures on an existing or nearby site.

Civil Site Visits

When a new structure is needed to be installed at an earth station location due to the C-band transition, at least one civil site visit will be required and, depending on the complexity of the construction, multiple return visits may be needed. Costs and complexity of preparing zoning and prosecuting zoning applications will vary by site and are dependent on local ordinance, existing site conditions, and, perhaps, most importantly, the approval of neighbors adjacent to the property. Accordingly, costs to prepare zoning applications and prosecute such requests through approval should be reflected in the Cost Catalog for receive-only earth stations.

Power and Telco Utility Coordination

Underground trenching may be required to connect a new structure at an earth station location. For instance, trenching may be required to connect a new antenna to its headend building, particularly if that

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antenna is installed in a new location on the grounds or at a nearby location. In these instances, most local ordinances require earth stations to coordinate with utilities (power company, telco, fiber, natural gas, etc.). While on-site trenching is generally a straightforward activity involving the advance location and marking of existing underground utilities, in the event the trench is located at or near the site property boundaries, more extensive advance coordination may be required. It is also possible that re-location of existing conduits or other underground utilities supporting earth stations will be required, which will entail necessary supplemental costs and coordination. Such coordination costs should be reflected in the Cost Catalog for receive-only earth stations.

Figure 5. Table IV-D-2 Architecture/Engineering Costs

Cost Category	*Low*	*High*
Civil Site Visit & Lease Exhibit	$ 1,000	$ 1,500
Zoning Drawings	$ 950	$ 1,250
CDs - Co-Location (Per Carrier)	$ 1,500	$ 2,500
Lease Exhibit Revisions	$ 250	$ 250
CD Revisions (Major changes, i.e. compound shift or access road shift)	$ 1,500	$ 1,500
Power Utility Coordination	$ 750	$ 1,150
Telco Utility Coordination	$ 750	$ 1,150
Building Permit Submittal (not including jurisdiction fees)	$ 1,000	$ 1,250
Perform Engineering Study for New Operating Frequencies and Antenna & RF Equipment Development/Selection	$ 2,000	$ 15,000
Comprehensive Coverage Verification via Field Study, if needed	$ 21,000	$ 84,200
RF Exposure Measurements (for sites where post-construction measurements have customarily been required or conducted)	$ 3,150	$ 21,050

2.6. Survey Costs (Table IV-D-3)

When new antenna installations are needed at earth station locations, a site survey (and staking) often will be required to gather critical information prior to the work being performed. What's needed from the survey may vary from location to location, but surveys can collect data to determine whether the proposed installation will have line-of-sight with the domestic satellite arc or trigger local construction ordinances. It can assess the condition of the property. Similarly, surveys can evaluate available space for cabling, utilities, and associated construction vehicles for the activities needed to install the antenna. Surveys can also account for neighbor concerns and zoning restrictions. Survey and staking costs, which are included as potential expenses for Fixed Satellite operators should also be reflected in the Cost Catalog for receive-only earth stations at the same price range.

Figure 6. Table IV-D-3 Survey Costs

Cost Category	*Low*	*High*
Survey & 1-A	$ 2,500	$ 4,500
Title Review	$ 500	$ 600
Construction Staking	$ 1,000	$ 2,000

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Survey - Additional Access Road	$1/ft beyond 500'	
Survey Revisions (Major change, i.e. compound shift or access road shift)	$ 1,500	$ 1,500

2.7. Environmental Costs (Table IV-D-4)

The installation of a new antenna at an earth station location can incur environmental costs. In some cases, earth stations are located in, or are adjacent to, an environmentally sensitive location, including but not limited to wetlands, conservation areas, and/or locations where federally protected species reside. These locations may impose site-specific limitations with respect to the use of diesel fuel or natural gas generators. Generally, these sites are subject to pre-existing requirements, and new construction associated with new antenna installation could drive significant expenses, such as analyses that determine potential environmental damage and ways for it to be mitigated.

Costs associated with environmental considerations were included as potential expenses associated with Fixed Service migrations in Table IV-D-4. Since these expenses and their estimated costs are potentially applicable to the transition of earth stations as well, the Cost Catalog should reflect these are earth station costs too.

Figure 7. Table IV-D-4 Environmental Costs

Cost Category	*Low*	*High*
Environmental Site Visit Phase I ESA	$ 1,900	$ 2,500
NEPA Section 106 Environmental Review (Excludes Cultural Resources)	$ 2,000	$ 6,300
Cultural Resources (Reimbursed plus 10% pass through - Tribal Fees are TBD)	$ 2,250	$ 2,500
Desktop Scrub	$ 350	$ 400
NIER Letter	$ 1,250	$ 1,250
Geotechnical - Soil Boring and Report	$ 3,000	$ 4,500
Environmental Assessment, if Triggered by NEPA/Section 106 or for certain structures over 450 feet (cost in addition to NEPA Review)	$ 5,260	$ 10,520

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3. Additional Earth Station Migration Costs

While the preliminary Cost Catalog identified many expenses that receive-only earth stations could potentially incur as a result of the transition, there are other possible receive-only earth station transition expenses unaccounted for in the Cost Catalog. Similar to the costs that were identified in Section 2 earlier, these unidentified cost items may not be incurred, for example, by all MVPDs, or all of an affected MVPD's respective headends, but they are potential expenses tied to the transition for receive-only earth stations. Moreover, these expenses will frequently be necessary in order for MVPDs to be able to offer to their customers substantially the same service during and after the transition as they were able to before. These costs should be added to the Cost Catalog for receive-only earth stations and eligible for reimbursement, as explained more fully below.

NOTE: ☐ In the Tables in this section are new costs proposed to be added to Cost Catalog

3.1. Additional Power Splitters, Re-Peak Antenna (Add to Table III-A-1)

The transition will require MVPD receive-only earth station operators to swap out integrated receiver/decoders (IRDs), perhaps multiple IRDs within the same period. This switching process requires both the old and new devices to be running at the same time for an extended period of time. If an operator lacks enough available ports for both devices, they will need additional power splitters. Power splitters at MVPD headends may need to be replaced with new power splitters that have higher port counts to connect the new replacement equipment and maintain substantially the same service.

Separately, each MVPD earth station antenna should be re-peaked when satellites are located with their "center of box" operation prior to the transitions. This "re-peaking" involves re-aligning the antenna (azimuth, elevation, and polarization) with the expected path of the satellite to ensure that the downlink signal is optimized. Antennas that are augmented for dual- or triple-feeds will need to be re-peaked as a part of the process.

Figure 8. Additions to Table III-A-1: Retuning to Frequency in 4.0-4.2 GHz

Cost Category	*Low*	*High*
Additional Power Splitters	$ 100	$ 300
Re-peak Antenna (Center of Box)	$ 400	$ 700

3.2. Downlink Technology Upgrades (Add to Table V-A-2, and applicable to MVPDs)

The transition is expected to result in some satellite-delivered MVPD programming being offered in a different compression and/or modulation standard. This will require MVPD earth station operators to obtain new integrated receiver/decoders that can process the new signals. While new IRDs for downlink earth stations are accounted for in Table V-A-2, which we understand to apply to receive-only earth stations, they are not explicitly categorized as relevant costs that may be incurred by MVPD earth stations, but should be included as relevant costs for those operators. Having reviewed the presumed reasonable price ranges provided in the Cost Catalog, we have assumed that the cost category for IRDs relate only to the equipment costs.

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To ensure that MVPD earth stations can maintain service to their customers in the event of an IRD malfunction, MVPDs maintain onsite backup equipment. If an MVPD needs new IRDs as part of the transition, then they will also need a sufficient number of spares to handle these unpredictable events.

Integrating IRDs into the existing or new aggregation systems found at the MVPD earth station headend requires installation and configuration, and this is reflected in the preliminary Cost Catalog in Table V-A-2. Depending on the age of the aggregation equipment, there may need to be firmware/software upgrades performed in conjunction with the IRDs. This can be done onsite or remotely, if the necessary secure Internet access is available, but in either case, the MVPD earth station would incur installation and configuration costs distinct from those detailed in other sections.

Figure 9. Additions to Table V-A-2: Downlink Technology Upgrades

Cost Category	*Low*	*High*
Spare Integrated Receiver / Decoders Hardware (5% of Total IRDs Req'd)	$ 5,000	$ 35,000
On-Site IRD Installation (wiring, configuration, power up, and test), per IRD	$ 1,150	$ 3,000
Remote IRD Configuration, per Site	$ 500	$ 2,000

3.3. Additional Racks & Electrical Circuits (New Category)

Headends may not have adequate existing rack space to house the installation of new IRDs and other equipment that must replace existing equipment, while also housing all existing equipment that is needed to provide existing services to the customers. In order to maintain on-air operations during the cut-over, new racks will be required for the replacement systems. This also means new electrical circuits, wiring, and plug molding will be needed to be installed into the racks from the existing power service panels for each new rack used.

New racks and associated circuits may also be needed to accommodate new earth station equipment (preliminary Cost Catalog Table III-B-3), IRDs (preliminary Cost Catalog Table V-A-2), or other equipment such as ad insertion systems that will be housed on an ongoing basis at the end of the transition. Costs for these items are estimated based on a range of reasonable pricing that could be expected on a per-rack basis.

Figure 10. NEW TABLE: Additional Racks & Electric Circuit Provisioning

Cost Category	*Low*	*High*
Headend Rack for New Equipment	$ 2,500	$ 3,100
Electric Circuit Provisioning	$ 750	$ 1,100

3.4. Additional Operational Costs per Site (New Category)

Cost considerations that not present in the preliminary Cost Catalog, but highly relevant to MVPDs, are outlined in the table below and recommended for inclusion in the final Cost Catalog. Cost ranges are provided in Figure 11.

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3.4.1. Supplemental Airflow Reconfiguration & Optimization

As discussed before, MVPD earth stations in many cases will need new, high density processing equipment to be installed in their headends in order for them to be able to continue offering their customers substantially the same services after the transition. For those with older headends that were purpose built for analog video distribution, these new devices (e.g., blade servers or COTS devices) will require their headends to have different power and HVAC configurations than they currently support.

For example, legacy analog video devices leverage "ambient" non-directional cooling (i.e., as long as the headend equipment space is generally kept cool, the devices operate nominally). However, new equipment that will be required (e.g., servers) often require a "hot aisle/cold aisle" HVAC airflow distribution for operation. In these instances, cold air is presented to the "front" of the server and the hot air is expelled at the rear.

For those headends without this configuration – of which there are many – the equipment racks will need to be re-oriented so that the "front" of the devices face each other across the rows of racks. This requires considerable effort to move equipment to the appropriate configuration, including equipment that may not directly support new functionality but is still a critical activity for the transition. These activities may require third-party contractors to re-configure facilities for continued operations.

The airflow reconfiguration and optimization cost range provided in the table above assumes incremental work and investments needed to maintain the level of operations currently in place at MVPD headends. It should be noted, however, there could very well be instances where costs exceed the ranges suggested but are still reasonable for what is necessary for the transition. In particular, small rural headends may not have adequate power and HVAC to accommodate any new replacement equipment, including IRDs. In this case, significant investment in HVAC and power in excess of the ranges provided in the Cost Catalog may be required to maintain substantially the same service.

3.4.2. Temporary Power, HVAC and Space

As discussed, in order to avoid disruption to consumers, new and old equipment for providing substantially the same service to customers will need to be concurrently operational for a period of time. For some MVPD earth station operators this will also result in costs for temporary power, HVAC, and space. These costs are not currently reflected in the preliminary Cost Catalog.

Some headends may have adequate utilities to support their existing legacy cable equipment as well as the end state for the anticipated replacement equipment (IRDs, transcoders, RF filters, etc.), but these headends may be unable to support both sets of equipment running simultaneously; simultaneous operation may be necessary when the equipment needs to run to two separate antennas. As an example, in order to prevent service interruption(s) associated with powering off one system in order to provide adequate power for the replacement system, alternative sources of power must be found.

In these instances, the headend may require a temporary or supplemental power / HVAC system to help bridge the transition. It may require portable generators and/or air-conditioning systems that could be provided by a vehicle that later drives away once the transition has been completed. In any case, a need for temporary power, HVAC, and space would involve costs for earth stations that should be itemized as potential reasonable expenses in the final version of the Cost Catalog.

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3.4.3. Site Connectivity Upgrade

In the event that the location of an antenna installation as needed to maintain substantially the same service results in a placement at a significant distance from the headend, fiber connections must be utilized to connect the headend to the antenna. In these instances, the signal loss resulting from the distance of the antenna/LNB to the headend is excessive and cannot be overcome with RF amplification. The recommended approach is to install dedicated fiber connectivity from the LNB system to the headend if the situation arises.

3.4.4. Systems Design, Integration and Testing

Changes to the production environment or equipment at MVPD earth stations necessitated by the transition to maintain substantially the same service will require labor to develop designs, install the new systems, perform end-to-end testing, and validate that services are properly "cut-over" prior to completion of the transition. In some cases, this work may be relatively short in duration, but in other cases local system limitations will result in a more complex challenge and require more substantial effort over a longer-term to complete the transition. Many MVPDs do not have on-staff engineering or technical operations personnel to perform this work, requiring the use of contractors.

This effort would be distinct from any other installation-related costs outlined in the preliminary Cost Catalog Tables III-A-1, III-B-1, III-B-3, etc. that refer primarily to filter and antenna-related installation. The expertise required for these activities would be distinct from the teams responsible for the other design and installation categories, and to perform this work, the party responsible for the earth station's transition solution will need to retain one or more third parties.

These potential costs are not included in the Cost Catalog, and should be deemed potential expenses for MVPD earth stations.

Figure 11. NEW TABLE: Transition Operation Costs per Site

Cost Category	*Low*	*High*
Supplemental Airflow Reconfiguration and Optimization	$ 2,500	$ 10,000
Temporary Power, HVAC and Space	$ 2,500	$ 10,000
Site Connectivity Upgrade	$ 2,000	$ 8,000
Systems Design, Integration and Testing	$ 500	$ 14,000

3.5. Multiple Program Transport Streams (MPTS) Aggregation

3.5.1. Downstream MPEG Service Aggregation and Rate-Shaping (Incl. Labor to Configure)

After installation of one or more IRDs, the MVPD may need to aggregate the satellite-delivered feeds to provide 256QAM 38.8mb RF channels delivered into the cable plant to ensure substantially the same service following the transition. The cost items in the table MPTS Aggregation are also used to perform advertisement splicing on various cable networks, both SD and HD. A key requirement is that none of the RF QAMs carrying video services (MPTS) exceed 38.8mb (including overhead). The RF QAM channel could include up to 12 SD MPEG2 services, or 4 HD MPEG2 services.

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The aggregator and rate shaper are necessary because they can ingest sources from multiple IRDs and select channels to multiplex together for ease of distribution along with ad splicing. Without them, substantially the same service cannot be achieved, warranting addition of these cost categories to the Cost Catalog.

Figure 12. NEW TABLE: MPTS Aggregation

Cost Category	*Low*	*High*
MPEG Aggregation Device (e.g., CAP100 - DCM - Prostream)	$ 27,000	$ 32,000
MPEG Aggregation Rate Shaping (for 3 HD or 12 SD MPEG-2 streams)	$ 500	$ 500
MPEG Aggregation with Ad Splicing (License Fees 1 SD, 1 HD MPEG2)	$ 1,500	$ 1,500
Downstream Rate Shaping Adjustments (Software, Firmware)	$ 2,000	$ 5,000
Ad Insertion System - Spot Inserter (20-50 Channels)	$ 80,000	$ 200,000

3.5.2. Downstream Rate Shaping Adjustments

Due to the changes made at the IRD output with transcoding and multiplexing, downstream rate shaping equipment may need to be adjusted to support the changes and ensure the continuation of substantially the same service. Firmware and/or software may be needed to also support such new configurations. These costs, which MVPD earth stations may reasonably incur as part of the transition should be included in the Cost Catalog.

3.5.3. Ad Insertion Equipment

Local Ad Insertion systems typically reside in the headend for standalone systems, or on a network for backbone delivery. These are unique to the local market in which the channel insertion is programmed to occur. A typical system can be assumed to have insertion occur on 12 standard definition linear channels for the purposes of illustrating the labor requirement.

Each channel could potentially be fed by a different IRD as single program transport stream (SPTS), for which the bit rate is capped at 3 Mbps each for a total utilized bandwidth of 36 Mbps, accounting for some excess capacity. A local Ad Insertion system must be configured to allow all local interstitials to occur simultaneously as a worst-case scenario. In this instance, all of the interstitials must be set at the same capped bit rate (3 Mbps).

When the new IRDs are installed as a result of the transition, there will often be different bit rates for the services as they adjust to the compression efficiencies associated with AVC or HEVC. This means that the "outputs" may be considerably smaller than they were before the transition (e.g., 2 Mbps per channel instead of 3 Mbps). Additionally, the channels may be "multiplexed" together by the MVPD network in a statistical multiplex (Stat Mux). For MVPD systems in which this occurs, the local interstitials must be reprogrammed to "fit" in the bandwidth when it changes as a result of the transition or the outputs of the IRDs will need to be transcoded to provide the same 3 Mbps channels as in the original IRDs.

These situations will require configuration to allow continued operation of the local Ad Insertion systems to ensure incumbent earth station operators continue to be able to provide substantially the same service to their customers during and after the transition.

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3.6. Workmanship Warranty

Typically, third-parties, for an extra price, will provide labor warranties on their work, assuring that, in the event of faulty workmanship / installation, the MVPD can recover some of its costs. This covers the operator in the case where changes are made to antennas, poor workmanship, and/or inferior products are used (e.g., incorrect concrete pads, improper antenna construction), and/or IRD equipment is improperly installed in racks (e.g., front to back airflow cooling, inappropriate wiring and connections). If faulty installation occurs by failure to follow industry-accepted best practices and guidelines, the contractor would be responsible to correct. With the C-Band Transition, in order for earth station costs to be truly reimbursed, warranties should be included as necessary costs where documented in requests for reimbursement because purchase of such warranties is standard industry practice. Otherwise, necessary costs associated with the transition will be imposed on the earth station operators without compensation.

Figure 13. NEW TABLE: Workmanship Warranty

Cost Category	*Low*	*High*
1-Year Workmanship Warranty for Filter, Antenna, & related activities (5% of Labor)	$ 500	$ 5,000
90-Day Workmanship Warranty for IRDs, Routers, & associated electronics (5% of Labor)	$ 500	$ 5,000

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4. Proposed Lump Sum Amount

Establishing an MVPD Lump Sum Category

The Order requires that the Bureau adopt lump sum amounts for different earth station categories based on the average, estimated costs that an earth station operator in that category may incur as a result of relocating its earth stations. The Order gave as candidate example categories MVPD earth stations, non-MVPD earth stations, and gateways without making a decision on what the right categories should be. The preliminary Cost Catalog, diverging from the examples in the Order, outlined specific types of earth stations, based on antenna size and receive-only vs. bi-directional vs. gateway stations, for which Lump Sum reimbursement would be possible.

Cartesian evaluated necessary modifications and upgrades for various MVPD configurations in detail with a selection of ACA Connects members, other cable operators, vendors, programmers, and satellite providers to understand key dependencies of the transition. A key takeaway was that the antenna dimensions by which the Bureau preliminarily categorized earth stations is unlikely to be a strong determinant of transition costs for most MVPD earth stations. More specifically, while antenna size is one factor for consideration, more important are the volumes of antennas that will be required, facility readiness for new equipment (e.g., adequate space for installations, where required), and the channels currently received and distributed by the headend.

We expect non-MVPD receive-only earth stations to have a substantially different profile with respect their transition requirements, such as number of antennas, associated IRDs, and other infrastructure equipment. For example, OTA broadcasters (sports backhauls), programmers downlinking their "program return" (used for uplink validation), and retail stores downlinking source content for in-store displays will not require the same level of equipment and support.

As a result, we have focused on proposing an inclusive MVPD earth station category for Lump Sum reimbursement on a per-headend basis.

Methodology for MVPD Lump Sum

The Order directs the Bureau to announce a lump sum amount based on the average, estimated cost to relocate incumbent earth stations within a given category of earth station to the upper 200 megahertz of the 3.7-4.2 GHz Band. In order to calculate a lump sum amount for the MVPD earth station category that we recommend above that the Bureau adopt, we relied upon our industry expertise and on numerous discussions we recently had with ACA Connects members, several larger non-member MVPDs, and other stakeholders with extensive knowledge and experience in the MVPD industry about the architecture and operation of MVPD earth stations and what the transition would entail.

In short, our estimate, which we detail below, was based on good engineering practice and available information. We develop a profile of an "average" MVPD earth station for lump sum purposes. We do not claim that there are any earth stations that meet this profile exactly. However, based on our research as explained above, we looked for those characteristics that we expect to be sufficiently common in transitioning MVPD headends to the upper 200 megahertz – i.e., occurring in approximately fifty percent (50%) of cases or more – so as to include them in constructing a lump sum calculation to reflect the "average" transition of the "average" earth station. In order to account for the requirement that, during and after

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the transition, space station operators provide substantially the same service to that which is currently being provided to MVPD customers today, we have included in the lump sum expenditures that address reliability and uptime. In particular, antenna configurations and sizes, equipment costs as well as associated space, power and HVAC requirements have been included in our analysis.

As a result of our approach, the unusual cost an earth station transition might involve in moving to the upper 200 megahertz, whether it was a large or small ticket item, was excluded from the calculation entirely – which is not to say, of course, that it would not be a necessary and reasonable expense in some number of earth station relocations, and therefore reimbursable outside the lump sum context. In those cases where multiple units of equipment, systems, associated work, or other cost categories would be involved in a sufficiently common number of cases to be part of the lump sum calculation, we applied our expertise, research, and experience to provide a conservative but reasonable number of occurrences for the ”average” earth station transition. As for the cost used for each of the expenses that were included under this approach to arrive at a lump sum recommendation, we used the arithmetical mid-point of the range for that cost category.

We believe this approach provides the most reasonable means of estimating the lump sum for the MVPD category at this juncture. We recognize that other more aggressive approaches for calculating lump sum amounts may exist, but they would have required an extensive, costly, and time-consuming survey and were not, in any event, possible within the limited time required to meet the FCC’s demands, nor could they have been meaningfully undertaken without knowing the final transition plans of space station operators. Indeed, in a related vein, our analysis makes certain technical assumptions and it would be appropriate to revisit them once the space station operators’ draft and/or final transition plans are available.

NOTE: ☐ in the Tables below are new costs proposed in section 3 to be added to Cost Catalog relevant to receive-only earth stations

4.1. Retuning Activities

Transitioning MVPD receive-only earth stations to the upper 200 megahertz of the 3.7-4.2 GHz Band will require a series of retuning activities. Sections 4.1.1 through 4.1.3 will detail the justification for inclusion of the individual cost items in Figure 14 in the lump sum calculations, reasoning for the quantities selected, and a calculation of the average cost for MVPDs on a per-headend basis.

Figure 14. Lump Sum Cost Categories: Retuning to Frequency in 4.0-4.2 GHz

Cost Category	*Average Price*	*Average Quantity*	*Lump Sum Sub-Total*
Replace Passband Filter	$ 650	24	**$ 15,600**
Passband Filter Installation (for two low-noise block converters [LNBs])	$ 700	12	**$ 8,400**
Acquisition of Ladder or Bucket Truck	$ 3,000	1	**$ 3,000**
Additional Power Splitters	$ 200	15	**$ 3,000**
Re-peak Antenna (Center of Box)	$ 550	4	**$ 2,200**

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4.1.1. Replace Pass-band Filters

Updated filters are required for all C-Band downlink antenna systems to eliminate RF interference. Forty-six (46) of the top fifty (50) Principal Economic Areas (PEAs), in the event of accelerated relocation by space station operators, will undergo a two-phase process for passband filter installation. The first phase will involve clearing the initial 120 megahertz, with attendant filter installations, and then another set of filter installations to clear the remaining 180 megahertz of the 3700-4000 MHz range. MVPD earth stations who do not serve the 46 PEAs involved in the two-phase approach will require one round of filter installation. While this will cause a number of MVPD earth stations to require twice the volume of filters, our estimates indicate approximately 25% of MVPD earth stations are located within those 46 PEAs, and as a result we have not increased the assumption of required filters.

Assuming the average MVPD earth station is downlinking content from 12 satellites, with two polarizations, the migration will require an average of 24 filters. Pending more detailed information as part of the preliminary transition plans that will be filed in June 2020, we are prepared to revise this estimate.

4.1.2. Pass-band Filter Installation and Ladder/Bucket Truck

Passband filter installation costs are quoted in the Cost Catalog as relevant "for two low-noise block converters [LNBs]," so 24 filters will require 12 installations for the average MVPD earth station. The cost of a bucket truck to place the antenna at the desired location is also necessary to include in the lump sum.

4.1.3. Power Splitters & Re-Peaking

Estimated volume of power splitters is related to potential needs given the number of replacement IRDs, polarization changes, and new satellite dishes. The actual count required could be higher depending on myriad factors, and can be revised pending further transition plan details. However, 15 power splitters can be assumed as an average requirement for MVPD earth stations.

Additionally, we include the cost of re-peaking efforts based on our estimate that the average MVPD earth station will require re-peaking for up to eight (8) antennas, which excludes the three (3) new and two (2) replacement dishes that have peaking integrated into the installation costs. Without further details on the specific transition plans, we have taken an average view of four (4) antennas that will require re-peaking efforts.

4.2. New Antenna Requirements

MVPD needs with respect to the type and size of new antennas at their earth stations will vary, but the core considerations will be ensuring that service remains substantially the same following the transition. Following detailed conversations with a range of MVPDs on their current and projected site configurations to accommodate the transition, it is clear that the average MVPD earth station will require multiple new antennas of a larger size to ensure there is no degradation of the service they are able to provide their customers from levels provided today.

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Figure 15. Lump Sum Cost Categories: Receive Only Earth Station Equipment

Cost Category	*Average Price*	*Average Quantity*	*Lump Sum Sub-Total*
Dual-feed System			
4.5m Antenna with a Dual-Feed System 4 PLL LNBs Pipe Mount Hardware; Installation and Instruction Manuals (per unit)	$ 13,750	5	**$ 68,750**
Supporting Equipment			
Antenna Installation or Move with Foundation Includes foundation materials, equipment rental and logistics/freight	$ 11,000	5	**$ 55,000**
C-Band Feedhorn Installation (for Single, Dual, or Triple-feed)	$ 450	5	**$ 2,250**
Additional Cable & Other Spare Equipment for Install (cable length dependent)	$ 1,900	5	**$ 9,500**
Shipment of Antenna Equipment (size of antenna and shipping distance dependent)	$ 3,000	5	**$ 15,000**
Trenching for Cable for Antenna Installation (if needed)	$ 1,600	5	**$ 8,000**
Mount Upgrade Options	$ 1,350	5	**$ 6,750**
De-Icing System	$ 5,300	5	**$ 26,500**

4.2.1. 4.5M Antenna with a Dual-Feed System

On average, an MVPD earth station will require a total of five (5) 4.5m antennas, including three (3) new ones and two (2) replacements of existing 4.5m antennas for the majority of headends. Our use of 4.5m antennas for the "average" MVPD earth station is explained below.

New Antennas

A successful C-Band migration that maintains substantially the same service needs to preserve an adequate RF link budget margin unilaterally across the CONUS footprint, and given the time-sensitive nature of the C-Band migration, a 4.5m downlink antenna solution will be necessary for the average earth station.

Given that the Order dictates that substantially the same service needs to be maintained for MVPDs following the transition of their earth stations from the lower 300 megahertz of the C-Band frequency spectrum, it is necessary to utilize "uptime" performance as a key metric to determine whether this has been achieved. An uptime metric can be defined as inclusive of the programmer, uplink, satellite, and downlink cumulative performance (i.e., a single measure of end-to-end signal delivery). This metric is measured as outage time as a percentage of total possible uptime. Industry benchmarks call for "four 9's" (99.99%) of uptime (i.e., service without outages), which equates to no more than ~53min of total outage time per year.

When programmers replace or upgrade video compression, modulation, or other related uplink components as part of the transition in response to changes by space station operators, the uptime performance impacts on legacy MVPD earth stations may be dramatic. These changes will have a direct

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impact to the resulting space-to-Earth link budget (i.e., the strength and characteristics of the resulting downlink RF signals), and the performance of many smaller antennas (<4.2 m) will be negatively impacted.

While many factors such as G/T antenna system performance, LNB noise temperature, weather, cable types and lengths, proper antenna peaking, local RF interference, and other downstream component performance can all adversely impact uptime, by far the most significant factors on signal uptime performance at the downlink are downlink antenna size and overall antenna gain performance. Individual and highly localized performance requirements notwithstanding, a uniform approach to maintain substantially the same downlink antenna signal acquisition performance for earth stations with smaller antennas pre-C-Band Transition would be achieved by using the proven solution of a 4.5m antenna.

Our lump sum calculations include only costs associated with 4.5m antennas because this approach ensures MVPDs will be able to deliver substantially the same service. The three (3) new satellites we understand are planned by SES and Intelsat will require three (3) new antennas for MVPD earth stations.

Small Earth Station Antenna Replacements

By way of further illustration of the impact antenna size could have, if a programmer migrates on its uplinks from MPEG 2 compression and QPSK modulation to MPEG 4 (AVC) and 8PSK modulation as a result of the C-Band transition, there can be serious impacts to downlink antenna performance for smaller antennas, and the problem would be further exacerbated if a programmer chooses to migrate to HEVC.

Due to these risks, replacement of existing antennas with larger (4.5m) antennas will be necessary to maintain performance and achieve substantially the same service that smaller antennas make possible today as a result of the C-Band transition as today. Overall system G/T performance (i.e., antenna gain) will be assessed on a per-earth station basis to determine if the existing legacy antennas need to be replaced outright, or if supplemental changes can be made to improve performance, but the average earth station will likely require multiple antenna replacements.

Based on conversations with MVPDs on their current configurations, we have assumed an average of 10 downlink antennas (3.7m and smaller) per headend site today. Taking into account that satellite operators have suggested approximately 20% of programmers will be making compression and/or modulation changes as part of the C-Band transition, a reasonable expectation is that two (2) replacement of 4.5m antennas will be required (20% of the 10 existing antennas) at MVPD earth stations on average.

Adding together the new and replacement antennas, we have accounted for five (5) new antennas per earth station in the lump sum calculation.

4.2.2. Supporting Equipment Costs

Installation, shipping, trenching, mount upgrades, and de-icing systems are accounted for on a 1-to-1 basis given the required five (5) antennas in the lump sum calculation.

4.3. IRD / Transcoders

The volume of IRDs and associated equipment, systems, and work that will be needed for the “average” MVPD earth station depends on whether and the extent to which programmers will change their uplink

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compression, encoding, and modulation platforms in the transition. It is difficult to assess this prior to the submission of detailed transition plans from the space station operators. However, our conversations with satellite operators suggest up to 20% of programmers will need to migrate services to a new uplink technology to achieve bandwidth efficiency and reduce transponder footprint as a result of the C-Band Transition.

In any instance where a programmer migrates to new uplink technology, all MVPD earth stations that currently receive that programmer's content will be required to install new IRDs to maintain substantially the same service as before the C-Band Transition.

Given the wide variety of IRD types and vendors, the most important determination is whether new IRDs will be configured in a 1:1 manner (i.e., a single source satellite input) or in a denser configuration such as 4:1 (i.e., four transponders per IRD). The latter configuration would allow a single IRD to receive up to four satellite inputs.

These distinctions inform both the price and quantity of necessary equipment, and numerous engineering requirements will dictate the appropriate choice for each headend. Interviews with several industry vendors planning to provide these new IRDs resulted in list cost pricing which is within the range provided as part of the Cost Catalog.

Figure 16. Lump Sum Cost Categories: Downlink Technology Upgrades

Cost Category	*Average Price*	*Average Quantity*	*Lump Sum Sub-Total*
Integrated Receiver / Decoders (IRD), per transponder	$ 12,000	26	**$ 312,000**
Spare Integrated Receiver / Decoders Hardware (5% of Total IRDs Req'd)	$ 12,000	2	**$ 24,000**
On-Site IRD Installation (wiring, configuration, power up, and test), per IRD	$ 2,075	28	**$ 58,100**
Remote IRD Configuration, per site	$ 1,250	1	**$ 1,250**

Following conversations with various MVPDs on their current channel counts and expected proportion of channels undergoing compression/modulation, we have assumed the average earth station receives approximately 52 satellite channels that will precipitate programmer changes which, in turn, will require 26 new IRDs (assuming 2:1 model on average). Using list price quotes at our disposal, we have estimated a cost of $12,000 per IRD, on average. This falls toward the lower end of the $5,000-$35,000 estimate provided in Table V-A-2 of the Cost Catalog. In addition, per Section 3.2 above, two spare IRDs (~5% of total required) are included for the average MVPD earth station in keeping with industry best-practices.

The estimates for on-site installation of IRDs is applicable to each IRD, as well as the spares to ensure they are "racked and ready" for use, and assumes the mid-range of estimated cost for those activities. Once installed, IRDs can be remotely configured (assuming an internet connection is available) and those costs must be accounted for in the lump sum.

Finally, given the bulk of new IRDs are also capable of transcoding signals, whereby the source inputs (MPEG-4, HEVC, etc.) are converted by the IRD to the required output (MPEG-2, composite video, IP etc.), we did

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not include any explicit transcoding costs in the lump sum. In what we understand to be the most common outcome, significant changes to the downstream headend plant would be avoided.

4.4. Headend Racks & Electric Circuits

Given the extent of the new equipment that will be required for the average MVPD earth station (e.g., new Routers, switches, IRDs (26+2 spares), ad insertion, etc.), the typical earth station will require four (4) additional racks and associated electric circuit provisioning. A single rack can typically support 8 IRDs, along with additional routers and switches. Given the amount of equipment required, we include the cost of 4 additional racks in the lump sum payment.

Figure 17. Lump Sum Cost Items: Additional Racks & Electric Circuit Provisioning

Cost Category	*Average Price*	*Average Quantity*	*Lump Sum Sub-Total*
Headend Rack for New Equipment	$ 2,800	4	**$ 11,200**
Electric Circuit Provisioning	$ 925	4	**$ 3,700**

4.5. Additional Lump Sum Costs

The costs outlined in Section 4.1 – 4.4 account for the bulk of the lump sum amount for the average MVPD headend. There are a number of additional costs detailed below that are similarly reasonable, necessary, and aligned with the views shared in discussions with ACA Connects members and larger non-member MVPDs. Combined with our engineering experts' extensive knowledge and experience in the MVPD industry, we find that these costs are relevant for inclusion in any calculation of the average lump sum amounts.

Figure 18. Additional Lump Sum Cost Categories & Assumptions

Cost Category	*Average Price*	*Average Quantity*	*Lump Sum Sub-Total*
Repointing Costs (from Table III-A-2)			
Install Portable or Trailer-mounted Antenna	$ 2,650	1	**$ 2,650**
Replace Cabling from Antenna to Headend	$ 1,600	1	**$ 1,600**
Travel Costs for Rural, Mountainous, Hard-to-Reach Areas (per trip)	$ 825	2	**$ 1,650**
Labor Fee for Installations or Emergency Situations (per hour)	$ 550	2	**$ 1,100**
Planning for Dual Illumination	$ 20,000	1	**$ 20,000**
Small Antenna Equipment Costs (from Table III-B-2)			
Cable Junction Box	$ 2,250	5	**$ 11,250**
Lightning Kit	$ 1,250	5	**$ 6,250**
Earth Station Equipment Costs (from Table III-B-3)			
Additional Line Cards for Transition	$ 8,000	1	**$ 8,000**
Core Network Components - Routers, Switches, Server (per component)	$ 15,500	1	**$ 15,500**

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Platform and Network Installation/Testing	$ 13,000	1	**$ 13,000**
Modification Application Cost (from Table III-D-1)			
Application to Modify Existing Earth Station License and Coordination Report	$ 3,500	1	**$ 3,500**
Relocation Project Costs (from Table IV-B-1)			
Project Management of the Transition, if needed (cost per hour)	$ $130	40	**$ 5,200**
Architecture / Engineering Costs (from Table IV-D-2)			
Civil Site Visit & Lease Exhibit	$ 1,250	1	**$ 1,250**
Power Utility Coordination	$ 950	1	**$ 950**
Telco Utility Coordination	$ 950	1	**$ 950**
Survey Costs (from Table IV-D-3)			
Survey & 1-A	$ 3,500	1	**$ 3,500**
Construction Staking	$ 1,500	1	**$ 1,500**
Environmental Costs (from Table IV-D-4)			
Environmental Site Visit Phase I ESA	$ 2,200	1	**$ 2,200**
Transition Operations Costs (Proposed in Section 3.4)			
On-Site Project Management	$ 2,250	1	**$ 2,250**
Supplemental Airflow Reconfiguration and Optimization	$ 6,250	1	**$ 6,250**
Temporary Power, HVAC and Space	$ 6,250	1	**$ 6,250**
Site Connectivity Upgrade	$ 5,000	1	**$ 5,000**
Systems Design, Integration and Testing	$ 7,250	1	**$ 7,250**
Workmanship Warranty Costs (Proposed in Section 3.4)			
1-Year Workmanship Warranty for Filter, Antenna, & related activities (5% of Labor)	$ 2,750	1	**$ 2,750**
90-Day Workmanship Warranty for IRDs, Routers, & associated electronics (5% of Labor)	$ 2,750	1	**$ 2,750**
		Total Lump Sum Costs:	**$ 764,500**

4.6. Total Lump Sum Amount

Aggregating all of the sub-total costs above results in a recommended lump sum amount of $764,500 per earth station for the MVPD earth station category.

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5. Appendix: Updated Cost Catalog Tables

NOTE: ☐ = New Cost Proposed in Section 3 to Be Added to Cost Catalog Relevant to Receive-Only Earth Stations

R = Costs Relevant for Receive Only Earth Stations Found Elsewhere in Preliminary Cost Catalog (See Section 2)

L = Costs Included in Lump Sum Amount (See Section 4)

5.1. II. Satellite Operator Costs

Figure 19. Table II-A-1: Satellite Repacking

Cost Category	Low	High
Engineering and Execution Labor	$ 150,000	$ 350,000

Figure 20. Table II-B-1: Expected Total Costs for Satellite(s) Delivered In-Orbit

Cost Category	Low	High
2 Tandem Launched C-Band Space Satellites	$ 240,000,000	$ 768,000,000
1 Single Launched C-Band Satellite	$ 120,000,000	$ 450,000,000

Figure 21. Table II-C-1: Satellite Procurement of 1 Satellite

Cost Category	Low	High
1 C-Band Satellite for Replacement/Diversification	$ 89,000,000	$ 205,000,000
Satellite Procurement Program Management (per Satellite)	$ 5,000,000	$ 8,000,000

Figure 22. Table II-C-2: Launch Costs

Cost Category	Low	High
Launch per Satellite (Dual Launch)	$ 36,000,000	$ 83,000,000
Launch per Satellite (Single Launch)	$ 63,000,000	$ 104,000,000

Figure 23. Table II-C-3: Consulting Fees

Cost Category	Low	High
Satellite System Engineering Planning	$ 25,000	$ 75,000
Coordination of New Satellite	$ 35,000	$ 125,000

Figure 24. Table II-C-4: Attorney Fees

Cost Category	Low	High
Prepare and File FCC Forms	$ 1,500	$ 5,000
Prepare and File ITU Forms	$ 5,000	$ 20,000

Figure 25. Table II-C-5: Filing Fees

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Cost Category	Low	High
FCC Satellite Application Filing Fee	$ 136,930	$ 136,930

Figure 26. Table II-C-6: Finance & Insurance

Cost Category	Low	High
Cost to Finance Satellite	$ 3,500,000	$ 11,000,000
Cost to Finance Launch	$ 2,000,000	$ 5,000,000
Insurance	$ 15,000,000	$ 30,000,000

Figure 27. Table II-D-1: Program Management

Cost Category	Low	High
Cost to Manage Satellite Relocation Program	$ 200,000	$ 400,000

5.2. III. Earth Station Migration and Filtering Costs

Figure 28. Table III-A-1: Retuning to Frequency in 4.0-4.2 GHz

Cost Category	Low	High	
Replace Passband Filter	$ 400	$ 900	R L
Passband Filter Installation (for two low-noise block converters [LNBs])	$ 300	$ 1,100	R L
C-Band Phase Locked Loop (PLL) LNB	$ 500	$ 1,100	R
Perform Retuning	$ 400	$ 700	R
Acquisition of Ladder or Bucket Truck	$ 500	$ 5,500	R L
Retrofit a Dual-feed onto a Single-feed Antenna	$ 1,000	$ 2,200	R
Retrofit a Triple-feed onto a Single-feed Antenna	$ 1,500	$ 3,300	R
Fiber Transmitter	$ 1,500	$ 2,800	R
Fiber Receiver	$ 1,500	$ 2,800	R
Fiber Optic Chassis	$ 1,500	$ 3,300	R
Chassis Frame Controller	$ 1,000	$ 2,200	R
Additional Power Splitters	$ 100	$ 300	R L
Re-peak Antenna (Center of Box)	$ 400	$ 700	R L

Figure 29. Table III-A-2: Repointing to a Different Satellite

Cost Category	Low	High	
Perform Repointing	$ 400	$ 1,000	R
Uplink Filter	$ 500	$ 1,500	R
Low Noise Amplifier/Block Downconverter	$ 250	$ 600	R
Upgrade/Change Polarization	$ 300	$ 600	R
Install Portable or Trailer-mounted Antenna	$ 2,000	$ 3,300	R L
Filter for Seeded Antenna	$ 400	$ 900	R

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Filter Installation in Seeded Antenna	$ 600	$ 1,100	R
Filter Installation in Spare Antenna (if seeding antenna is not needed)	$ 600	$ 1,100	R
Initiate operations via Dual Illumination (with seeded and spare antenna)	$ 500	$ 12,000	R
Replace Cabling from Antenna to Headend	$ 1,000	$ 2,200	R L
Travel Costs for Rural, Mountainous, Hard-to-Reach Areas (per trip)	$ 150	$ 1,500	R L
Labor Fee for Installations or Emergency Situations (per hour)	$ 300	$ 800	R L
Planning for Dual Illumination	$ 10,000	$ 30,000	R L
Dual Illumination of Transponder	$ 10,000	$ 24,000	R

Figure 30. Table III-A-3: Gateway - RF Uplink Chain

Cost Category	*Low*	*High*
RF Uplink Chain for Limited Motion Antenna Configuration		
Solid State Power Amplifier	$ 75,000	$ 340,000
Block Upconverter (BUC)	$ 35,000	$ 45,000
Fiber System 45,000 – 55,000	$ 45,000	$ 55,000
RF Distribution 25,000 – 35,000	$ 25,000	$ 35,000
RF Uplink for Extended/Full Performance Antenna Configuration		
Travelling Wave Tube Amplifier 75,000 – 260,000	$ 75,000	$ 260,000
BUC 35,000 – 45,000	$ 35,000	$ 45,000
Fiber System 25,000 – 35,000	$ 25,000	$ 35,000
RF Distribution 25,000 – 35,000	$ 25,000	$ 35,000

Figure 31. Table III-A-4: Gateway & Receive Only - RF Downlink Chain

(Preliminary Cost Catalog Table Name: "Gateway - RF Downlink Chain")

Cost Category	*Low*	*High*	
RF Downlink Chain for Limited Motion Antenna Configuration			
Block Downconverter (BDC)	$ 35,000	$ 45,000	
Fiber System	$ 45,000	$ 55,000	
RF Distribution	$ 15,000	$ 25,000	
RF Downlink Chain for Limited Motion Antenna Receive Only Configuration			
Fiber System	$ 45,000	$ 55,000	
RF Distribution	$ 15,000	$ 25,000	
RF Downlink Chain for Extended/Full Performance Antenna Configuration			
Block Downconverter (BDC)	$ 35,000	$ 45,000	
Fiber System	$ 45,000	$ 55,000	R
RF Distribution	$ 15,000	$ 25,000	

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Figure 32. Table III-B-1: Receive Only Earth Station Equipment

Cost Category	*Low*	*High*	
Single-Feed System			
3.7m Antenna with a Single-Feed System 2 PLL LNBs Pipe Mount Hardware; Installation and Instruction Manuals (per unit)	$ 4,000	$ 6,600	R
4.2m Antenna with a Single-Feed System 2 PLL LNBs Pipe Mount Hardware; Installation and Instruction Manuals (per unit)	$ 8,000	$ 12,000	R
4.5m Antenna with a Single-Feed System 2 PLL LNBs Pipe Mount Hardware; Installation and Instruction Manuals (per unit)	$ 9,000	$ 16,400	R
Dual-feed System			
3.7m Antenna with a Dual-Feed System 4 PLL LNBs Pipe Mount Hardware; Installation and Instruction Manuals (per unit)	$ 5,000	$ 7,700	R
4.2m Antenna with a Dual-Feed System 4 PLL LNBs Pipe Mount Hardware; Installation and Instruction Manuals (per unit)	$ 9,000	$ 13,100	R
4.5m Antenna with a Dual-Feed System 4 PLL LNBs Pipe Mount Hardware; Installation and Instruction Manuals (per unit)	$ 10,000	$ 17,500	R L
Triple-feed System			
3.7m Antenna with a Triple-Feed System 4 PLL LNBs Pipe Mount Hardware; Installation and Instruction Manuals (per unit)	$ 5,500	$ 8,200	R
4.2m Antenna with a Triple-Feed System 6 PLL LNBs Pipe Mount Hardware; Installation and Instruction Manuals (per unit)	$ 95,000	$ 13,700	R
4.5m Antenna with a Triple-Feed System 4 PLL LNBs Pipe Mount Hardware; Installation and Instruction Manuals (per unit)	$ 10,500	$ 18,000	R
Supporting Equipment			
Antenna Installation or Move with Foundation Includes foundation materials, equipment rental and logistics/freight	$ 5,000	$ 17,000	R L
C-band Feedhorn Replacement	$ 150	$ 600	R
C-band Feedhorn Installation (for Single, Dual, or Triple-feed)	$ 300	$ 600	R L
Additional Cable & Other Spare Equipment for Install (cable length dependent)	$ 500	$ 3,300	R L
Shipment of Antenna Equipment (size of antenna and shipping distance dependent)	$ 500	$ 5,500	R L
Trenching for Cable for Antenna Installation (if needed)	$ 1,000	$ 2,200	R L
Mount Upgrade Options	$ 1,000	$ 1,700	R L
Snow Cover (3.7M)	$ 500	$ 1,100	R
De-Icing System	$ 4,000	$ 6,600	R L

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Figure 33. Table III-B-2: Receive Only - Near Full-arc Multibeam Antenna Equipment

Cost Category	*Low*	*High*	
Small Antenna: Reflector Replacement			
Replace Reflector	$ 70,000	$ 80,000	R
Cable Junction Box	$ 2,000	$ 2,500	R L
Full Reflector Heating System	$ 20,000	$ 25,000	R
Lightning Kit	$ 1,000	$ 1,500	R L
Reflector Installation	$ 9,000	$ 10,500	R
Small Antenna: Complete System			
Small Reflector and Standard Mount	$ 125,000	$ 140,000	R
Foundation Kit	$ 2,000	$ 2,500	R
C-band Dual Polarity Feed Assembly (per feed)	$ 1,500	$ 2,500	R
C-Band PLL LNB (per feed)	$ 500	$ 1,100	R
Cable Junction Box	$ 2,000	$ 2,500	R
Full Reflector Heating System	$ 20,000	$ 25,000	R
Lightning Kit	$ 1,000	$ 1,500	R
Full System Installation	$ 9,000	$ 10,500	R
Shipping and Handling	$ 15,000	$ 17,000	R
Large Antenna: Complete System			
Large Reflector and Standard Mount	$ 400,000	$ 475,000	R
Foundation Kit	$ 3,500	$ 4,500	R
C-band Dual Polarity Feed Assembly (per feed)	$ 1,500	$ 2,500	R
C-Band PLL LNB (per feed)	$ 500	$ 1,100	R
Cable Junction Box	$ 4,000	$ 4,500	R
Full Reflector Heating System	$ 55,000	$ 65,000	R
Lightning Kit	$ 2,000	$ 2,500	R
Full System Installation	$ 70,000	$ 80,000	R
Shipping and Handling	$ 25,000	$ 30,000	R
Supporting Equipment			
Passband Filter	$ 400	$ 900	R
Multi-beam Bubble Cover Kit	$ 1,000	$ 3,300	R
Feed Peaking Kit	$ 500	$ 1,100	R
C-band Ortho Mode Transducers	$ 1,000	$ 2,200	R
C-band Antenna Feed Assembly (per feed)	$ 1,500	$ 2,200	R
2 Cables with 4 Connectors (Cable length dependent)	$ 500	$ 3,300	R

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Figure 34. Table III-B-3: Bi-directional & Receive Only Earth Station Equipment

(Preliminary Cost Catalog Table Name: "Bi-directional & Receive Only Earth Station")

Cost Category	*Low*	*High*	
Duplication of Hub Platforms for Transition - Single Site	$ 200,000	$ 1,500,000	
Additional Line Cards for Transition	$ 6,000	$ 10,000	R L
Additional Modems for Transition	$ 2,000	$ 8,000	R
Additional Chassis	$ 3,000	$ 10,000	R
Core Network Components - Routers, Switches, Server (per component)	$ 1,000	$ 30,000	R L
Platform and Network Installation/Testing	$ 9,000	$ 17,000	R L
2.4-3.0M Tx/Rx Antenna Terminal	$ 2,500	$ 18,000	
3.7M Tx/Rx Antenna Terminal	$ 10,000	$ 30,000	
4.5-6M Tx/Rx Antenna Terminal	$ 25,000	$ 45,000	
6M Tx/Rx Antenna Terminal / Non-Pen	$ 60,000	$ 200,000	
BUC 2W to 80W (outdoor unit)	$ 2,000	$ 20,000	
BUC 100W-300W (outdoor unit)	$ 20,000	$ 40,000	

Figure 35. Table III-B-4: Temporary Fixed Uplink Earth Station Equipment

(Preliminary Cost Catalog Table Name: "Temporary Fixed Uplink Earth Station")

Cost Category	*Low*	*High*
4.5M Transmit Antenna / Non-Pen	$ 25,000	$ 45,000
Shipping & Installation	$ 10,000	$ 15,000
Upconverter/Modulator	$ 50,000	$ 75,000
High Power Amplifier	$ 75,000	$ 170,000

Figure 36. Table III-B-5: Gateway Equipment

Cost Category	*Low*	*High*
7.3m Limited Motion Antenna (LMA)		
7.3m LMA	$ 550,000	$ 700,000
7.3m LMA Installation	$ 150,000	$ 250,000
7.3m LMA System Integration	$ 250,000	$ 300,000
7.3m LMA Receive Only System Integration	$ 80,000	$ 120,000
13m LMA		
13m LMA	$ 950,000	$ 1,100,000
13m LMA Installation	$ 350,000	$ 500,000
13m LMA System Integration	$ 250,000	$ 300,000
13m Extended Performance Antenna (EPA)		
13m EPA	$ 1,550,000	$ 1,950,000

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13m EPA Installation	$ 350,000	$ 500,000
13m EPA System Integration	$ 250,000	$ 300,000
13m Full Performance Antenna (FPA)		
13m FPA	$ 2,900,000	$ 3,100,000
13m FPA Installation	$ 450,000	$ 600,000
13m FPA System Integration	$ 250,000	$ 300,000
Supporting Equipment		
Network Routers	$ 55,000	$ 200,000
Program Management for Antenna Installation	$ 60,000	$ 210,000

Figure 37. Table III-C-1: Consolidation of TT&C

Cost Category	*Low*	*High*
13m Antenna System (full motion, calibrated) - Single Antenna	$ 1,500,000	$ 2,000,000
Antenna Installation - Single Antenna	$ 600,000	$ 733,000
Timing System	$ 36,000	$ 105,000
Baseband Unit	$ 100,000	$ 600,000
Test Loop Translator	$ 25,000	$ 75,000
Digital Interfacility Link to Existing Teleports for Translation to Baseband	$ 700,000	$ 800,000
Land/Facility Acquisition	$ 500,000	$ 2,500,000
Site Infrastructure Buildout	$ 75,000	$ 250,000

Figure 38. Table III-D-1: Expected Total Costs for Earth Stations (Any Earth Station)

(Preliminary Cost Catalog Table Name: "Expected Total Costs for Earth Stations")

Cost Category	*Low*	*High*	
Receive Only Earth Station Relocation Cost	$ 39,000	$ 80,000	R
Receive Only Multi-beam Earth Station Relocation Cost	$ 180,000	$ 590,000	R
Bi-directional Earth Station Relocation Cost	$ 200,000	$ 1,600,000	
Temporary Fixed Earth Station Relocation Cost	$ 150,000	$ 310,000	
Gateway System Relocation Cost	$ 2,100,000	$ 4,500,000	
New Earth Station License Application and Coordination Report	$ 5,000	$ 8,000	
Application to Modify Existing Earth Station License and Coordination Report	$ 3,000	$ 4,000	R L

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5.3. IV. FIXED SERVICE COSTS

Figure 39. Table IV-A-1: Fixed Service Retune Only Total Costs

Cost Category	Low	High
Permanent Fixed Link Relocation Cost 2,000 – 25,000	$ 2,000	$ 25,000
Temporary Fixed Link Relocation Cost 1,500 – 15,000	$ 1,500	$ 15,000

Figure 40. Table IV-B-1: Earth Station Relocation Project Costs

(Preliminary Cost Catalog Table Name: "Fixed Service Relocation Project Costs")

Cost Category	Low	High	
Project Management of the Transition, if needed (cost per hour)	$ 62	$ 200	R L
Address Transition Timing and Coordination Issues with Other License Holders, if needed	$ 850	$ 2,750	R
Prepare and/or Review Reimbursement form	$ 250	$ 2,750	R
Comprehensive Study/Verification of Link Performance and Reliability, if needed for new electromagnetic environment	$ 2,750	$ 19,500	

Figure 41. Table IV-B-2: FCC Filing Fees (adjusted biennially)

Cost Category	Low	High
New, Renewal or Renewal/Modification FCC Form 601/159 Application Payment/Fee (Per Call Sign)	$ 305	$ 305
New, Renewal or Renewal/Modification FCC Form 601/159 Regulatory Payment/Fee (Per Call Sign)	$ 250	$ 250
Special Temporary Authorization Request	$ 140	$ 140
Extension of Construction Authority FCC Form 601/159 Application Payment/Fee (Per Call Sign)	$ 110	$ 110

Figure 42. Table IV-B-3: Consulting/Attorney Fees

Cost Category	Low	High
Prepare and File Engineering Section of FCC Form 601 (Schedule I)	$ 1,000	$ 5,250
Prepare and File Engineering Section of FCC Form 601 (Schedule K)	$ 500	$ 2,250
Prepare and File Special Temporary Authorization	$ 1,000	$ 3,500

Figure 43. Table IV-C-1: Fixed Service Equipment for Single Microwave Path

Cost Category	Low	High
Channel Filters	$ 450	$ 2,100
Indoor Radio Pair	$ 6,000	$ 26,000
Modem Pair	$ 650	$ 5,500
Microwave Antennas - 2 Parabolic Dish Antennas	$ 2,880	$ 24,200
Outdoor Units - 2 Radios and Enclosures	$ 1,000	$ 7,750

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Microwave Network Management System Equipment (server and redundant server hardware)	$ 20,000	$ 30,000
Miscellaneous Materials (e.g. waveguide, dehydrator, grounding, DC to DC Converter, Racks, PDUs, Disposal, Delivery, Storage and Handling)	$ 3,000	$ 25,000

Figure 44. Table IV-C-2 Installation/Pathing/Testing Costs

Cost Category	*Low*	*High*
Microwave Changeout per Elevation (one site, each hop is two sites); includes feedlines and sweep testing	$ 28,000	$ 38,000
Microwave Pathing	$ 12,000	$ 16,000
Radio, Modem and Cabling	$ 5,000	$ 7,000
Microwave Dish Antenna	$ 10,000	$ 15,000
Waveguide, Jumpers and Connectors	$ 3,000	$ 5,000
Dehydrator System	$ 1,000	$ 1,500
DC Breaker Installation	$ 400	$ 600
New Ground Bar for Waveguide	$ 700	$ 1,000
New Ice Bridge from Shelter to Tower	$ 6,000	$ 8,000
Dish Alignment	$ 2,500	$ 3,500
Radio Acceptance Testing	$ 4,000	$ 6,000

Figure 45. Table IV-C-3 RF Engineering Costs

Cost Category	*Low*	*High*
Perform Engineering Study for New Operating Frequencies and Antenna & RF Equipment Development/Selection	$ 2,000	$ 15,000
Comprehensive Coverage Verification via Field Study, if needed	$ 21,000	$ 84,200

Figure 46. Table IV-D-1 Earth Station Site Acquisition Costs

(Preliminary Cost Catalog Table Name: "Site Acquisition Costs")

Cost Category	*Low*	*High*	
Search Ring for new viable tower or ground space, confirm zoning and permitting process, site candidate application in existing asset, lease package or ground lease	$ 7,500	$ 10,000	R
Obtain building permits from local zoning authorities (cost of preparation, submission and prosecution of necessary forms or applications)	$ 1,500	$ 6,000	R
Obtain local permits other than for zoning (cost of preparation, submission, and prosecution of necessary forms or applications)	$ 500	$ 2,500	R

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Figure 47. Table IV-D-2 Architecture/Engineering Costs (Any Earth Station)

(Preliminary Cost Catalog Table Name: "Architecture/Engineering Costs")

Cost Category	*Low*	*High*	
Civil Site Visit & Lease Exhibit	$ 1,000	$ 1,500	R L
Zoning Drawings	$ 950	$ 1,250	R
CDs - Co-Location (Per Carrier)	$ 1,500	$ 2,500	R
Lease Exhibit Revisions	$ 250	$ 250	R
CD Revisions (Major changes, i.e. compound shift or access road shift)	$ 1,500	$ 1,500	R
Power Utility Coordination	$ 750	$ 1,150	R L
Telco Utility Coordination	$ 750	$ 1,150	R L
Building Permit Submittal (not including jurisdiction fees)	$ 1,000	$ 1,250	R
Perform Engineering Study for New Operating Frequencies and Antenna & RF Equipment Development/Selection	$ 2,000	$ 15,000	R
Comprehensive Coverage Verification via Field Study, if needed	$ 21,000	$ 84,200	R
RF Exposure Measurements (for sites where post-construction measurements have customarily been required or conducted)	$ 3,150	$ 21,050	R

Figure 48. Table IV-D-3 Survey Costs (Any Earth Station)

(Preliminary Cost Catalog Table Name: "Survey Costs")

Cost Category	*Low*	*High*	
Survey & 1-A	$ 2,500	$ 4,500	R L
Title Review	$ 500	$ 600	R
Construction Staking	$ 1,000	$ 2,000	R L
Survey - Additional Access Road	$1/ft beyond 500'		R
Survey Revisions (Major change, i.e. compound shift or access road shift)	$ 1,500	$ 1,500	R

Figure 49. Table IV-D-4 Environmental Costs (Any Earth Station)

(Preliminary Cost Catalog Table Name: "Environmental Costs")

Cost Category	*Low*	*High*	
Environmental Site Visit Phase I ESA	$ 1,900	$ 2,500	R L
NEPA Section 106 Environmental Review (Excludes Cultural Resources)	$ 2,000	$ 6,300	R
Cultural Resources (Reimbursed plus 10% pass through - Tribal Fees are TBD)	$ 2,250	$ 2,500	R
Desktop Scrub	$ 350	$ 400	R
NIER Letter	$ 1,250	$ 1,250	R
Geotechnical - Soil Boring and Report	$ 3,000	$ 4,500	R
Environmental Assessment, if Triggered by NEPA/Section 106 or for certain structures over 450 feet (cost in addition to NEPA Review)	$ 5,260	$ 10,520	R

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Figure 50. Table IV-E-1: Fixed Service Expected Total Costs

Cost Category	Low	High
Retune Permanent Fixed Link Relocation Cost	$ 2,000	$ 25,000
Retune Temporary Fixed Link Relocation Cost	$ 1,500	$ 15,000
Replacement - Permanent Fixed Link Relocation Cost	$ 30,000	$ 290,000
Replacement Temporary Fixed Link Relocation Cost	$ 15,000	$ 150,000

5.4. V. Technology Upgrades

Figure 51. Table V-A-1: Uplink Technology Upgrades

Cost Category	Low	High
Encoding / Statmux Equipment (per transponder)	$ 275,000	$ 1,210,000
Modulation and Coding Equipment (per transponder)	$ 50,000	$ 85,000

Figure 52. Table V-A-2: Downlink Technology Upgrades

Cost Category	Low	High	
Integrated Receiver / Decoders (IRD), per transponder	$ 5,000	$ 35,000	R L
Spare Integrated Receiver / Decoders Hardware (5% of Total IRDs Req'd)	$ 5,000	$ 35,000	R L
On-Site IRD Installation (wiring, configuration, power up, and test), per IRD	$ 1,150	$ 3,000	R L
Remote IRD Configuration, per site	$ 500	$ 2,000	R L

5.5. New Cost Categories

Figure 53. Additional Racks & Electric Circuit Provisioning

Cost Category	Low	High	
Headend Rack for New Router Equipment	$ 2,500	$ 3,100	R L
Electric Circuit Provisioning	$ 750	$ 1,100	R L

Figure 54. Transition Operation Costs per Site

Cost Category	Low	High	
Supplemental Airflow Reconfiguration and Optimization	$ 2,500	$ 10,000	R L
Temporary Power, HVAC and Space	$ 2,500	$ 10,000	R L
Site Connectivity Upgrade	$ 2,000	$ 8,000	R L
Systems Design, Integration and Testing	$ 500	$ 14,000	R L

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Figure 55. MPTS Aggregation

Cost Category	Low	High	
MPEG Aggregation Device (e.g., CAP100 - DCM - Prostream)	$ 27,000	$ 32,000	R
MPEG Aggregation Rate Shaping (for 3 HD or 12 SD MPEG-2 streams)	$ 500	$ 500	R
MPEG Aggregation with Ad Splicing (License Fees 1 SD, 1 HD MPEG2)	$ 1,500	$ 1,500	R
Downstream Rate Shaping Adjustments (Software, Firmware)	$ 2,000	$ 5,000	R
Ad Insertion System - Spot Inserter (20-50 Channels)	$ 80,000	$ 200,000	R

Figure 56. Workmanship Warranty

Cost Category	Low	High	
1-Year Workmanship Warranty for Filter, Antenna, & related activities (5% of Labor)	$ 500	$ 5,000	R L
90-Day Workmanship Warranty for IRDs, Routers, & associated electronics (5% of Labor)	$ 500	$ 5,000	R L

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Cartesian is a specialist consulting firm in the telecoms, media and technology sector. For 30 years, we have advised clients worldwide in strategy development and assisted them in execution against their goals. Our unique portfolio of consulting services and managed solutions are tailored to the specific challenges faced by executives in these fast-moving industries. Combining strategic thinking, robust analytics, and practical experience, Cartesian delivers superior results.

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For further information, please contact us at cartesian@cartesian.com

EXHIBIT

CHRISTOPHER P. PATTERSON

Professional Experience

SEMI-RETIRED, SELF-EMPLOYED CONSULTING AND CONTRACTING **12/18/2017 – Present**

Industry-specific projects.

COMCAST CORPORATE, West Chester PA 19380 **06/01/2012 – 12/17/2017**

Executive Director Video Quality and Reliability

I worked with a team of people in association with other Comcast engineering groups on improving and maintaining video quality leveraging technological improvements to allow for higher compression rates with MPEG2 and MPEG4. We regularly reviewed and tested the quality to assure the higher video performance and reliability across the Backbone and CRAN network. We also headed up the replacement of the headend equipment modernizing the architecture to aid in the improvement of quality and reliability. Worked with markets on provisioning space, power, UPS, Generator HVAC requirements as headend services expanded.

Responsibilities:

- Manage project capital
- Develop and deploy new network infrastructure products and services
- Evaluating in order to improve video quality and reliability
- Assist with Digital Video Architecture Engineering
- Establish procedures for video quality testing
- Aided the field in upgrading and replacing their headend equipment
- Provided oversight on facility space, power, UPS, Gen, and HVAC requirements

COMCAST EASTERN DIVISION ENGINEERING, Oaks PA 19456 **01/19/2000 – 05/30/2012**

Vice President of Engineering

I managed a team of 7 direct reports with a department of 20 team members with the responsibility of engineering and operating new technology deployments and implementations. The Division oversees 5 regions across 5 States PA, NJ, DE, MD, and VA comprising of 5.2 million Comcast subscribers. At Comcast all levels of the organization share full responsibility and accountability to the subscriber experience. Our 2007 capital budget was > $1b.

Responsibilities:

- Strategic planning
- Manage project capital
- Develop and deploy new network infrastructure products and services
- Assist with the development of year over year capital and expense budget
- Implement engineering compliance and technical excellence programs
- PMO Project Management

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- Digital Video Architecture Engineering
- Network Transport CRAN Engineering
- Conditional Access – Motorola DAC/SA DNCS
- E2E Capacity Management
- VOD - On Demand Application Engineering
- 3rd Party fiber agreements and commercial services
- LMC Local Management Center - NOC

Accomplishments:

- Designed and implemented VOD - On Demand services enabling On Demand to 4 million digital converters:
  - 65% Motorola Conditional Access
  - 35% Scientific Atlanta Conditional Access
  - 90% Seachange ITV Systems
  - Small deployment of Tandberg-Broadbus in 3 markets
- Collaborated, designed and built Multi State CRAN - Converged Regional Area Network with Nortel, Movaz, and Cisco CRS and 7609 Routers at 10g-40G capacity. Integrates with National CBone and IBone networks:
  - Redundant converged traffic - CDV, HSD, UET-ADS video multicast traffic
  - Non redundant VOD links
  - Back office MIS and IT traffic
- Designed and Deployed ADS -All Digital Simulcast enabled on 4 million digital converters:
  - Bigband BMR, Terayon, Motorola and SA deployments on SEM, MQAM and GQAM systems
  - C-Cor ad insertion
  - 110 ad zones
  - Also deployed UET unencrypted transport network for all digital multicasts
- Built team to develop E2E end 2 end capacity management program:
  - Products and services HSD, VOD, CDV, CRAN
  - PSTN, all network transports
  - Facilities - space, power , UPS, Gen, HVAC
- Assisted in developing the LMC Local Management Center Engineering Operations model IP and Video Support. “Ongoing”:
  - Helped baseline demarcation points
  - Severity level assignments
  - IP and Video Service Desks

SUBURBAN CABLE TELEVISION/LENFEST COMMUNICATIONS CORPORATE 10/1996 – 01/2000

Vice President of Engineering and Technical Operations

Managed a team of 85 engineering and technical operations personnel maintaining over 20,000+ miles of HFC plant with 1 primary master along with 9 secondary headends and 35 OTNs. My team and I were responsible for operating, upgrading and maintaining all of the HFC plant and headends servicing 1.2 million subscribers across 3 states PA, NJ and DE. The annual capital budget last year prior to transition to Comcast was $225 million.

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Responsibilities:

- Strategic planning
- Mentor and develop engineering and technical operations team
- Build up engineering and technical operations department in centralized model
- Managed capital, purchasing and procurement department
- Operate and maintain HFC plant servicing 1.2 million customers
- Establish engineering compliance for all headends and OTNs.
- Deploy new technologies

Accomplishments:

- Develop HFC Design Department – Maintained all records in AutoCAD mapping – format
- Launched Cisco CMTS HSD service with @Home
- Launched Digital Services to 1.2 million subscribers on Motorola DAC - DCT-2000 platform
- Transitioned through Y2K
- Upgraded 3000 miles of 750 MHz HFC plant at Node + 5 – 500 HHP
- Performed Trial with DIVA VOD system

SUBURBAN CABLE TELEVISION/LENFEST COMMUNICATION – SE PA/NJ Region 6/1987 – 10/1996

Regional Engineer

Managed a team of system engineers and technical operations personnel in support of the SE Region for Suburban Cable comprising of Delaware County PA and South Jersey. The 2 operations supported 3200 miles of plant, maintained 2 primary headends and several OTNs. The region was formed through several acquisitions at the time in both PA and NJ.

Accomplishments:

- Maintained engineering and technical operations
- Converted all maps to AutoCAD format
- We were the first in Suburban system to consolidate headends utilizing fiber technology
- Upgraded 1200 miles of conventional coaxial plant to 550 MHz HFC architecture supporting 2000 HHPs
- Initiated plant reliability project to eliminate AEL along with upgrade all fused amplifiers to improve plant powering performance
- Established safety compliance program

TIMES MIRROR CABLE TV – Delaware County PA 01/1981 – 6/1987

Technical Management – Chief Technician

Handled day to day technical management for customer fulfillment, service and repair, line maintenance, and aerial/underground construction.

- Built and trained technical support staff
- Maintained conventional coaxial cable plant
- Maintained primary headend, off air, and satellite receive station
- Supported 6 GHz cars band and AML microwave system

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COMMUNICATION PROPERTIES INC – Delaware County PA **09/1978 – 01/1981**

Technician

Handled day to day customer fulfillment, service and repair, line maintenance, and aerial/underground construction.

Professional Development/Activities

- Society of Cable Telecommunications Engineers
- Comcast L&D programs
- Assorted Industry certifications over 39 years

Education

Accredited Pennsylvania Institute of Technology Media PA

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DAVID HIGGINS

Professional Experience

TECHNOLOGY CONSULTANT **1/18 – Present**

COMCAST **4/03 – 12/17**

Vice-President Technology Environments and Strategy *4/16 – 12/17*

Develop and execute $75M capex investment related to head-end and hub infrastructure upgrades.

- Identify legacy video TVRO sites strategically positioned for conversion to edge data centers.
- Manage investments in power (DC Plant conversions) and HVAC ("Hot Aisle/Cold Aisle", high density cooling racks) and building structural improvements.
- Execute capex spend and coordinate systems integration thru Division Engineering leadership.

Vice-President Quality Assurance *8/08 – 4/16*

Sr. manager of Comcast-wide Video Quality Initiative, IT Network Security, 24/7 Call Center and technical support teams.

- Propose, develop and manage execution of multi-year $500M capex investment strategy associated with service reliability enhancements including Network, Infrastructure, Video Processing and distribution, thru Division Engineering leadership, Corporate Finance and Procurement.
- Responsible for CALM Act audio loudness compliance initiative nationwide.
- Establish national Advanced Video Solutions group to design, test and integrate all local video infrastructure systems (DAC, DNCS, Prostreams, CAP 1000, encoding and compression).
- Establish 24/7 internal technical "hotline" for all local video infrastructure maintenance, troubleshooting.
- Manage IT Security initiative associated with CMC national video distribution center.

Vice-President Transmission Engineering and IT Operations *4/03 – 8/08*

Senior manager of Advanced Engineering, Broadcast Engineering, Transmission, Encoding, IT Operations and IT Security.

- Supervise 122 member staff supporting 24/7 technical operations including over 50 antennas at two teleports, 100 inbound terrestrial fiber paths, three data centers, three production studios, six Avid post-production suites, four digital audio edit rooms, five multi-channel origination rooms, two HD live events suites and a 30-channel live sports origination environment. Facilities provide over 400 full-time uplink services to an aggregate of over 100M+ TV households - as well as over 17K live feeds in 2007.
- Responsible for annual operating budget of $19M, development of department goals, objectives and metrics. Leverage assets to improve performance, identify systemic problems, mitigate failures, communicate effectively and grow the organization capacity through professional growth of staff.
- Evaluate and establish advanced engineering initiatives for Comcast including:

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  - Centralized distribution models for All Digital Simulcasting, linear HDTV distribution, Switched Digital Video, 3D broadcasting, VOD encryption and Video Rich Navigation.
  - Remote ingest of graphics, interstitials and long form video content for server-based play to air environments that can share media assets and serve as disaster recovery pods.
  - Deployment of video over IP for Comcast national fiber backbone delivery of linear content.
- Provide technical sales support for both internal Comcast Programming Investment channels including Comcast Sportsnet, VS. Golf, Sprout, AZN, TV One and external clients including BET, CSTV, Discovery, Indemand, Oxygen, Boeing, Navic and a variety of MSO's.
- Establish video quality test lab and facilitate national consumer research targeting both SD and HDTV linear channel delivery competitive analysis.

THE SYSTEMS GROUP **8/99 – 4/03**

Director Project Development

Senior Project Manager and Technology Sales Consultant for a variety of studio, post-production, master control origination and broadcast design and construction projects.

- Utilizing industry contacts, trade information and cold calls generate sales leads and business opportunities for design consulting and turn-key integration services.
- Manage client relationships including initial sales presentations, OOM pricing, contract documentation preparation, change order processing and executive level interface for business issues. Supervise client focus groups by creating and administering technical question sets, summary documentation and development of key design approaches.
- Develop detailed technical specifications, budgets, timelines and RFP's, based on client preferences, subsystems compatibility, risk analysis and equipment availability.
- Develop facility construction strategies by performing engineering and operational investigation, space planning, systems design and budget modeling. Deliverables include architectural plan views, systems flow drawings, facility descriptions and mechanical design targets for cable raceways, HVAC, grounding, electrical, structural, baseband and RF systems.
- Manage procurement process, vendor negotiations, system design, fabrication and integration efforts on a variety of consulting and turn-key installation projects for CourtTV, AT&T Digital Media Center, Oxygen Media, Music Choice, QVC, Bloomberg, Van Kampen Investments, Morgan Stanley, IBM, The Smithsonian Institute, WIPR TV, WIPM TV and WGBH TV.

PRIMESTAR, Inc.

Sr. Director Broadcast Operations *4/98 – 8/99*

Senior on-site manager responsible for24/7 broadcast control center and on-air operations quality control monitoring.

- Manage 53 direct reports supervising systems administration, network telecom, broadcast operations, traffic and scheduling, applications management and general facilities. Implement process controls and QOS initiatives including weekly call center coordination meetings, daily enterprise status meetings and escalation and notification protocols to manage day to day operations of the service

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platform including PPV, Regional Sports Networks, blackouts, short-form interstitials and commercial insertion.

Director of Engineering *5/95 – 4/98*

Technical Manager of satellite uplink and terrestrial fiber long haul providers. Supervise DTH consumer antenna hardware development and MPEG 2 next generation compression and encoding systems field testing.

- Supervise technical team migrating RF and baseband systems from K1/K2 satellites to GE2 (14 54 MHZ transponders to 24 new 36 MHZ transponders) while integrating 70 new service chains including downlinks, transmitters, diplxors, routers, monitoring and control systems and associated infrastructure.
- Evaluate compression techniques and various vendor solutions to develop next generation road-map recommendations to MPEG 2. Develop RF and baseband field test requirements for new MPEG 2 encoder/set-top decoder transmission platform.

IDB COMMUNICATIONS

Engineering Manager (Promoted to Director of Engineering) *10/92 – 5/95*

Manage a $1.5 M budget and 11 member staff supporting four 24/7 broadcast control centers, 23 satellite uplink antennas, long haul fiber interconnects, RF, baseband, data/telecom, monitor and control infrastructure as well as base building infrastructure.

Project Manager *11/90 – 10/92*

Manage design and integration of broadcast and telephony transmission projects for ABC Network, USA Network, Lifetime Network, MSG Network, CourtTV, CMT, Music Choice, CNBC, Viacom, INMARSAT and a variety of international clients.

Sampling of White Papers and Articles

- “MVPD Obligations for CALM Act” ATSC 2012
- “Quality of Service Still Remains Job #1”, Broadband Library Summer 2009
- “Developing a Grading System for Digital Video Quality”, presented at NCTA 2009 Cable Show
- “Integrating Centralized Digital Technologies for Optimum Quality” presented at NCTC Winter Conference 2007
- “Video-Rich Navigation: Hyperlinks to the Future”, presented at SCTE Emerging Technologies Conference 2006
- “Multicasting and the Growing Demand for Navigation using Video Mosaics”, presented at NAB 2006
- “Challenges Associated with Transitioning to All Digital” presented at SCTE Cable-Tech Expo 2006

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Education

School of Visual Arts, BFA 1983

FCC General Class Radiotelephone License, 1984

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